OPERATIVE
THERAPEUSIS

OPERATIVE THERAPEUSIS

EDITED BY

ALEXANDER BRYAN JOHNSON, Ph.B., M.D.

VOLUME III

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OPERATIVE THERAPEUSIS

VOLUME III

CHAPTER I

THE EYE

COLMAN W. CUTLER

EXAMINATION OF THE EYE

A systematic examination of the eye should be made whenever disease of the organ or its neighborhood is suspected and in cases where evidence may be expected relating to disease or injury of the brain or more distant parts.

It is not permissible for the examiner to assume that the signs of local or distant trouble will be found by the use of the ophthalmoscope or by the observation of the pupils or the motility of the eyes alone. Such an error can be avoided only by the use of a routine method which is simple and which should not be considered as making too great a demand on the patience of the surgeon in comparison with the value of the results.

Inspection.—Inspection includes examination of the surface of the lids and brow, the function of the facial nerve, ptosis, protrusion of the eyeball on one or both sides, or the opposite condition, enophthalmos. Any lack of symmetry between the two sides of the face should be noted, although it should be remembered that the two halves of the face are as a rule unsymmetrical in the level and arch of the brows especially, and not infrequently the action of the frontalis and the orbicularis varies slightly on opposite sides. The region of the lacrimal sac and the inner angle of the lids should be observed for signs of inflammation of the sac or of the anterior ethmoidal cells which may present here.

The inspection of the edges and inner surface of the lids, with eversion of the upper lid, for signs of inflammation, which may be a menace in traumatism or in operation on the eyeball, is most important. Conjunctivitis, dacryocystitis, and blepharitis (or inflammation of the lid margins) are frequent sources of infection when the corneal epithelium is abraded or the eye exposed by injury or incision.

It is not possible to deal with these conditions at length, but it must be stated emphatically that their existence is a contra-indication to operation, and in case of injury to the eyeball, the first effort must be directed to their control in order to prevent secondary infection.

Inspection of the eyeball is made with a lens with which the light from a lamp or candle is focused on the surface, or with a small flashlight, to which a convex lens is added, as in a simple device made by E. B. Meyrowitz. This method of oblique or focal illumination is indispensable in the examination of the eyeball. It should be practiced by everyone who deals with eyes in questions of diagnosis or treatment. It is so simple that description seems superfluous, yet it is often neglected, and small injuries, such as foreign bodies in the cornea, abrasions and ulcers, are overlooked.

The pencil of rays focused by the lens plays upon the cornea, the iris, the lens, and may even illuminate a tumor or exudate in the anterior portion of the vitreous. It is possible thus to study the epithelium, the stroma, the posterior surface of the cornea for exudate or scars, the surface of the iris and the pupil.

In no field of medicine is it of greater importance to recognize the early stages of disease. A minute lesion of the cornea may in a few hours become an ulcer which will leave a scar permanently affecting vision. The discovery of an iritis at an early stage will permit the use of atropin, thus preventing the formation of synechiæ. The circumcorneal flush of iritis, however, must be corroborated by the other cardinal symptoms of that disease: contracted and, usually, irregular pupil, hazy, aqueous, dull iris stroma and anterior chamber of normal or exaggerated depth, before atropin is used.

Glaucoma may also be accompanied by episcleral congestion and the pain of the two conditions may be the same, but in glaucoma the pupil is wide, the anterior chamber is shallow, and the eyeball is hard. It is needless to say that here the use of atropin would be a fatal mistake.

Such instances might be multiplied; they are not strictly within the limits of this article, but the importance of the subject is a sufficient excuse for calling attention repeatedly to the necessity of an early recognition of changes in the surface appearance of the eye.

In the inspection of the eye the movements of the eyes in all directions are to be noted. If the patient is directed to follow a light or the finger it can be determined whether both eyes fix or whether one lags, in which case a red glass is needed to study the nature of the diplopia which may be elicited. Convergence and the reaction of the pupils are included in the routine examination of the eye. The presence of ptosis and its association with local, orbital, cerebral or sympathetic lesions, must be noted.

Retraction of the lids, or inability to close the lids (lagophthalmus), is important, because, if the cornea is not protected by the lid, it becomes dry and the epithelium exfoliates. This exposure of the deeper layers leads to infection and suppuration. In facial paralysis and in coma, when the movements of the lids are lacking, the mucus of the conjunctiva collects and organisms increase; it is, therefore, necessary in these conditions to cleanse the eyes frequently or even to protect the eyeball by a light bandage which will hold the lids closed. This is especially necessary when the cornea is anesthetic, as in disease or removal of the Gasserian ganglion, or fracture or disease impairing the trophic influence of the trigeminus. In such cases vaselin with boracic acid or oxycyanid of mercury 1:5,000 should be put between the lids several times a day, great care being taken to avoid brushing the cornea with cotton or applicator, as the slightest abrasion may lead to a most intractable form of keratitis.

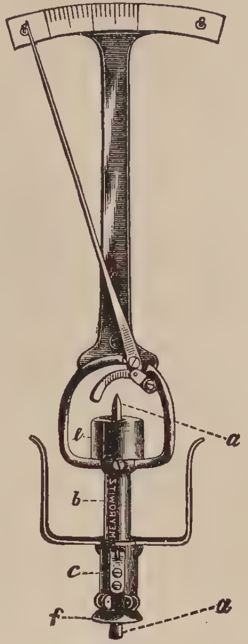


Fig. 1.—The Schiötz Tonometer. This instrument is designed to measure the intra-ocular pressure and to indicate it in terms of millimeters of mercury.

The part applied to the eye *f* is a concave surface corresponding to the average corneal curvature; *a* is a rod, moving freely in the sleeve *b* and whose upper end *d* in contact with the cam, operates the pointer. The instrument is supported between the fingers by means of the arms extending out from *c*.

By means of a series of weights ranging from 5.5 to 15 gr. the instrument is adapted to making very accurate readings in any degree of abnormal pressure.

A small model with a convex surface is furnished with each instrument, and the pointer is adjusted to indicate zero for this curve.

Palpation.—Palpation of the margins of the orbits, the ethmoidal and lacrimal regions, may detect faults in their contours or points of abnormal sensitiveness, cysts, abscesses and tumors.

Pressure on the eyeball may reveal resistance in the orbit and should be directed backward or toward the side of the orbit in order to estimate the elasticity or firmness, and the region of resistance.

Palpation of the eyeball to determine its tension is made through the closed lid, the patient looking downward. The index fingers are pressed very gently downward on the upper part of the globe, as if one were palpating a cyst. The tension of both eyes should be compared. The tension is raised in glaucoma, and lowered in injuries which have opened the globe and sometimes in contusions without rupture. In injured eyes, or when the cornea is ulcerated, if the tension is notably low there is danger of an escape of the contents of the globe, and palpation must be made with great delicacy or avoided altogether. One of the most perfect instruments that has been added to the armamentarium of the oculist is the tonometer of Schiötz, which has given a mathematical precision to the measurement of increased tension in glaucoma. It would be unfortunate, however, if the use of such an instrument should detract from the value of the tactus eruditus.

Measurements.—The measurement of the position of the globe may be important to determine the degree of exophthalmos. This may be estimated by looking at the eyes from the side and noting their prominence, but in order to record varying or increasing protrusion in tumors of the orbit or in exophthalmic goiter, the exophthalmometer is of value.

The distance of the eyes from the median line should be noted in tumors and cysts of the inner wall of the orbit.

Auscultation.—In cases of exophthalmos, especially those following fracture of the skull, auscultation should be practiced, the stethoscope being placed over the closed lid, the brow and the temples, to detect the bruit of an aneurysm.

Transillumination.—Transillumination of the globe enables us to determine the density of a mass within the eyeball by the interruption of the light transmitted through the dilated pupil from the point of the Wurdeman or Sachs transilluminator placed upon the anesthetised sclera. This method is of great value in detecting intra-ocular growths and differentiating them from exudate and translucent detachment of the retina.

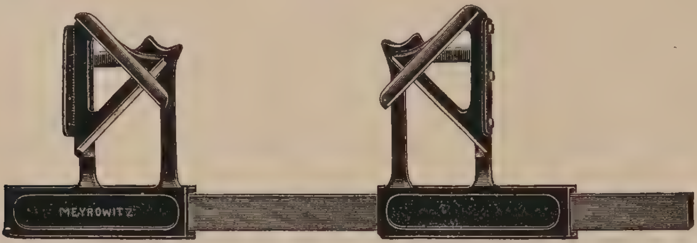


Fig. 2.—Exophthalmometer (Prof. Hertell). This is an instrument for measuring exophthalmia with accuracy and rapidity, and is useful in determining the progress of such protrusion in cases of intra-orbital tumor, goiter, foreign bodies and retrobulbar hemorrhage.

The instrument resembles a sliding rule, each member being provided with a scale reading 0 to 30 millimeters and two mirrors mounted at right angles and one above the other. When the instrument is in position, with the two points in contact with orbital margin, the profile of the cornea is seen in one mirror and scale in the other. The scale reading directly above the corneal image gives its protrusion in millimeters. Readings are made of one eye at a time.

The separation of the two members is shown on the slide. All measurements of the same case must be made with the members equally separated to the same reading on the sliding scale.

EXAMINATION OF VISION

Central Vision.—Central vision should be tested in order that changes indicating progress in the disease may be noted later. The same conditions of distance, light and test objects should be observed at successive tests. The patient should wear his distance glasses where it is possible, or it may be noted that the test was made "without correction." The most convenient test object is Landolt's reduced card or optotypes, or the ordinary Snellen letters may be used. Where the vision is much impaired the distance is noted at which fingers are counted or the movements of the hand are seen against the dark background of the coat, and if central fixation is lost it may be noted that vision is eccentric. The object of this test is to obtain a basis for future comparison rather than to determine the best or actual vision.

It is important, however, as Dr. de Schweinitz has well shown, to get the best possible vision with glasses before drawing conclusions regarding the function of the optic nerve and retina. This is especially true in choked disk and neuroretinitis dependent on intracranial disease, where the impairment of vision might be attributed to central causes, while in reality due to uncorrected errors of refraction.

Peripheral Vision.—Taking the field of vision is not a simple matter. The test is not merely a physical measurement of perception, as is the determination of central vision by means of the test types. It measures the perception of an area not accustomed to accurate judgment and makes demand on attention and intelligence which in the nature of the case may be deficient. The results vary with the degree of daylight, with the condition of the patient, as well as with the test objects used, so that tests on successive days, on the same patient, may show striking differences in the limits of the field for form and colors, and similar variations in the appearance of defects or scotomas in which the retinal elements or nerve fibers have been impaired but not destroyed. The test, therefore, makes demands on the patience and tact of the examiner, but it is of such importance that it should not be omitted from the routine to be followed in all cases of intracranial disease.

FIG. 3.—WURDEMAN'S TRANSILLUMINATOR.

The defect in the field may be an early symptom, before choked disk is pronounced. It is not necessary to wait for swollen nerves where other symptoms point to intracranial pressure. Choked disc is conclusive, but if an earlier sign is available in certain cases, such as the color interlacing described by Cushing, it must be looked for in all that are suspicious.

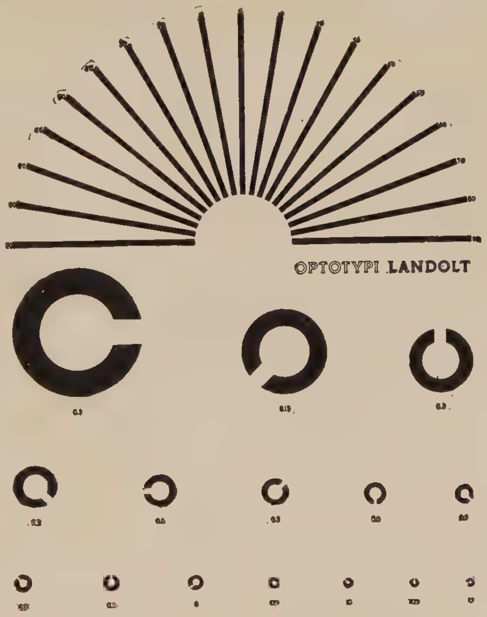


FIG. 4.—LANDOLT TEST-TYPES. These test-types particularly emphasize the principle of the test of vision, viz.: the smallest angle at which two points can be separately determined. Letters are as a matter of fact very unsatisfactory objects as tests of vision.

Landolt's test-types consist of black rings on a white ground, out of which a piece with parallel edges has been removed. The subject under test is then required to indicate by word or motion of hand, the place where the circle is broken. The diameter of the opening corresponds to the tangent of the angle of vision.

THE PERIMETER AND ITS USE.—Peripheral vision is examined by means of the perimeter. The choice of an instrument is of less importance than the selection of the colors and the observance of certain details without which the results are of little value.

Schweigger's hand perimeter is convenient for hospital use, especially where patients must be examined in bed. There must be ample daylight illuminating the test objects equally as they are moved to different parts of the arc. Artificial light does not permit accurate testing with colors, as the values of blue and red are changed.

Objects of different sizes are needed: Usually those having a diameter of 20, 10, 5, and 3 mm. suffice, although smaller objects of red and green may be needed to detect the central or paracentral scotomas of tobacco or alcohol amblyopia, and large objects may also be useful at times.

The choice of colors is important, and especially in view of the prominence given to interlacing of the red and blue fields by Dr. Cushing as a symptom of intracranial pressure. The colors used by me for several years are pure primary colors made by the Milton Bradley Co., and are to be had from E. B. Meyrowitz, 237 Fifth Avenue. They are the same in saturation, intensity, and surface as those recently offered by Dr. Clifford Walker. Disks or squares may be used, and it is not probable that the results will vary greatly.

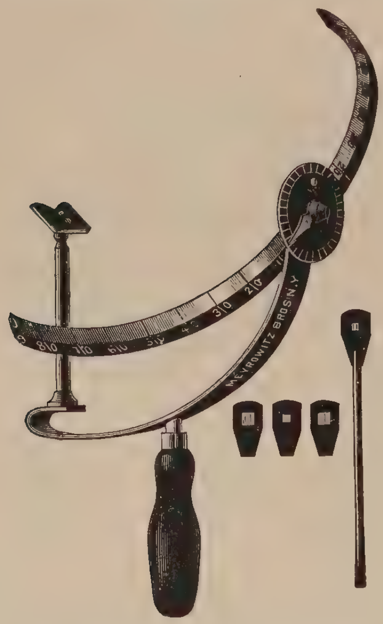


Fig. 5.—Schweigger's Perimeter.

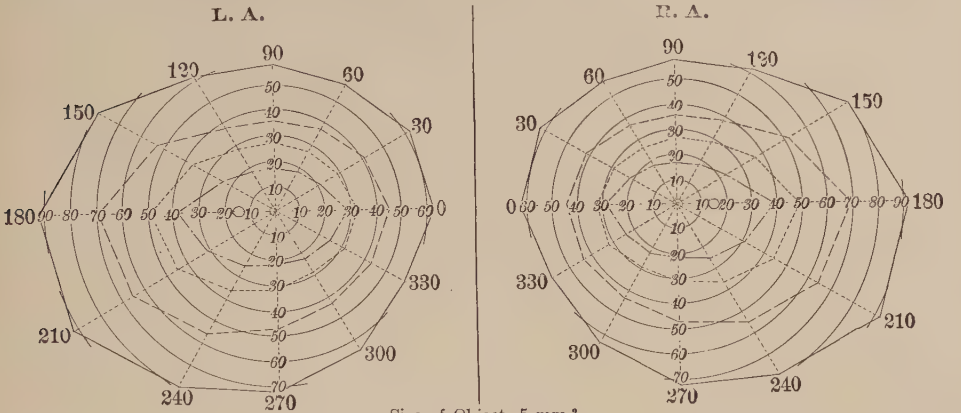
It is important to standardize methods as regards colors, sizes, and shapes of objects, but it is equally important to simplify the methods and materials so that surgeons and internes may not be deterred from making these very essential tests by needless complications. The simplest objects are thin squares of blackened wood of the sizes mentioned. On the opposite sides of each square are pasted a blue and a red paper covering the surface so that there is no margin. Another square on the opposite end of the slender blackened rod or holder carries green and white or gray papers. The squares can be made more cheaply than the disks and may therefore be the more readily replaced when the colors are dulled by use, an important consideration in hospitals.

The square object should be brought in along the arc of the perimeter with its straight edge parallel or tangent to the margin of the field, and in this way it becomes a better guide to the color perception than the curved edge of a disk.

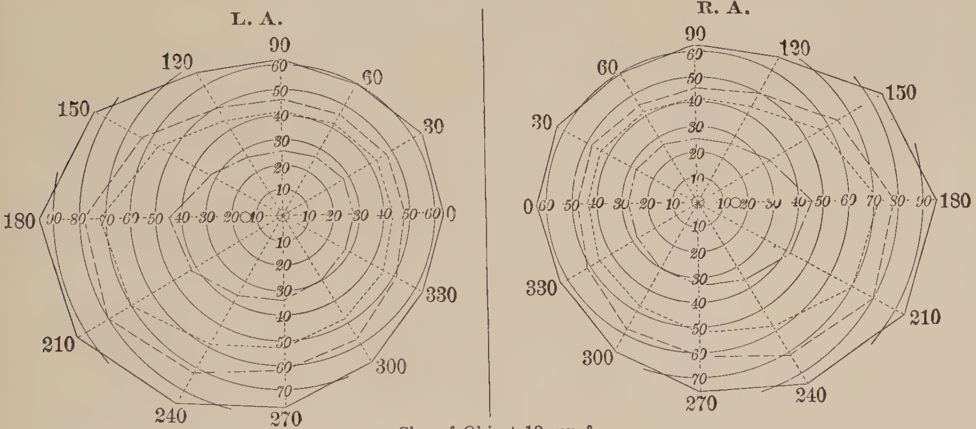
METHOD OF EXAMINATION.—The eye not examined is covered with cotton held by adhesive. It is important to avoid pressure, which impairs vision for some time, and it is also important to cover the non-fixing eye completely.

The patient fixes the center of the arc; the examiner, standing in front, should control this fixation rigidly. This is not easy when the intelligence or power of attention of the patient is impaired, but without accurate fixation the measurement of peripheral vision is misleading. If the patient glances toward the object as it is brought inward, his statement is ignored and the test must be repeated. The movement of the object should be steady, not so slow as to cause fatigue, and without oscillation.

It is best to begin with a blue object of 10 mm. If the daylight is good, this will be seen as a light spot at the periphery of the field, and this point is noted on the chart, and the same object is brought in until the blue color is recognized. The handle is then rotated, exposing the red surface, and brought in until this is recognized. If red is seen as soon as, or before, blue, the normal order is reversed and there is interlacing, to which attention has been called by Dr. Cushing. If blue is not recognized as a light object at the periphery, a gray or white object must be used, but the use of blue in cases where the field is normal, or nearly so, is equivalent to neutral gray and is a more delicate test than a white object. It also spares one step in the tedious process.



Size of Object. 5 $mm.^2$



Size of Object 10 $mm.^2$

FIG. 6.—SCHEME FOR FIELD OF VISION. (After Professor Grenouw.) Size of object, 10 $mm.^2$ Published by J. F. Bergmann, Wiesbaden.

Journal No..........................
Name..............................
Date...............................
Disease............................
....
Acuteness of vision....................

Field of vision for
White ————————
Blue — — — — — —
Red ....
Green — . — . — . —
Distance, 31 cm.

The cardinal principle in perimetry is to use the smallest and least striking object visible in the periphery of a normal eye under given conditions of light, and to choose larger and more conspicuous objects in proportion to the diminished function or mentality of the patient.

There must be no suggestion to the patient as to the color, and the rotation of the disk with alternation of the colors gray, blue, and red should be practiced to avoid a regular repetition of an order which would enable the patient to anticipate the color before it is seen.

The eye should be closed for a moment at frequent intervals to avoid fatigue. If the ophthalmoscope has been used, the eye must be allowed to rest for at least a quarter of an hour before the field is taken.

Aubert says: "When the eye is fixed on the central point of the perimeter, the peripheral zone of the retina becomes fatigued more quickly by color sensations than the central zone." This is especially true for colors, and it seems to apply to blue more than to red: For instance, in a prolonged perimetric examination, if the mental state of the patient is dull, or the attention wandering, a blue object is sometimes seen less readily in the periphery after several repetitions, while the stimulus of the red object of the same size and intensity is perceived promptly. This does not necessarily mean that the field for blue is narrowed, but it may explain some cases of interlacing of red and blue. It is most important, therefore, to alternate the colors, to give the eye frequent brief periods of rest, but not to be too deliberate.

Examination of Blind Spot.—The measurement of the function of the central portion of the retina is of even greater importance than that of the periphery, and it should be a part of all thorough examinations of the visual function.

The classical method is that of Bjerrum, on a screen at 1 or 2 meters distance, with small objects of 2 mm. and 5 mm. diameter.

For this test we are looking, first, for the sharp edges of absolute scotomas, such as the edge of the blind spot and defects that occur in glaucoma and toxic amblyopia; the smallest and brightest object is best, therefore, as Bjerrum first advised, but it adds to the value of the test if, after having determined the absolute area of a scotoma or the blind spot, we estimate the relative function of its margin for color or gray. We have not yet reached definite conclusions regarding the meaning of these defects, and a careful study of a large number of cases must be made and the progress of the visual defects watched in connection with the ophthalmoscopic picture, and especially with the changes in the accessory sinuses and the results of treatment.

The chief advantage of the Bjerrum test is the magnification of the blind spot and of all defects, because of the greater distance at which the test is made; the fault is the risk of imperfect fixation, but this is true of all perimetric tests.

The work of Van der Hoeve, De Kleijn and many others has called attention to the peripapillary scotoma or enlargement of the blind spot as a symptom of great importance in disease of the nasal sinuses.

In conclusion, the patient should not be fatigued, because both the attention and the perception suffer. In functional conditions, such as neurasthenia, it is easy to obtain very puzzling results if the test is prolonged. It is better, therefore, at the first attempt, to train the patient in the method and to make a quick test of the fixation point for white and colors and the horizontal and vertical dimensions of the blind spots, watching for signs of flagging attention, or for fatigue of the retina such as occurs in glaucoma. An evanescent blur or a relative scotoma may be marked on the reverse of the screen for future reference, without the knowledge of the patient, and returned to later for verification.

The mapping out of defects with as much precision as possible is important, as all changes in their shape and size are significant. The responsibility that rests on the ophthalmologist is not light. Upon his decision may depend the choice of a radical operation on the accessory sinuses or of a more conservative procedure.

The appearance of the optic nerve may not assist the diagnosis. In disease of the posterior ethmoid and sphenoid cells there may be no perceptible congestion or swelling of the nerve, and yet the enlargement of the blind spot must be considered an early and apparently a pathognomonic symptom. On the other hand, in an early stage of choked disk, where the nerve is hyperemic or even swollen, the blind spot may not be enlarged.

In glaucoma the presence of small paracentral scotomas are as significant as coarser defects in the periphery. De Schweinitz and Holloway have shown the importance of scotomas as an early symptom of hypophysis disease.

The measurement of the blind spot has been made with sufficient accuracy with white and with brightly colored objects to enable us to postulate a normal area, but with duller test objects or, what is practically the same, uncertain daylight, the limit of the fields above and below and beyond the blind spot, for small objects, may vary. It is important, therefore, for every one to accustom himself to his environment and to take a sufficient number of fields of normal eyes. The results are not absolute; they depend on many conditions, most of all on the patience of the examiner.

Relation of Vision to Cerebral Surgery.—A review of the relation of vision to cerebral surgery, however brief, would be incomplete without reference to Harvey Cushing's work on the pituitary body. The conclusions drawn from his carefully studied cases are given in a few paragraphs and should be read in connection with the case histories. Quotation, however, may be permitted:

> Dr. Cushing considers the visual disturbances to be the most common and, naturally, the most serious of all neighborhood signs. The optic nerves are apt to suffer in different forms of pituitary disease and the degree of implication of chiasm, nerves or tracts bears no direct relation to the size of the sella. This point is illustrated by a number of cases. For instance, in most of the acromegalics there was an enlarged sella without visual disturbance, while in the patients with primary hypopituitarism and chromophobe struma the visual disturbances were usually profound. The atrophy is a so-called primary one and the disk shows no edema except in the late stages, when

the growth has reached such a size as to lead to general pressure phenomena, due in the vast majority of instances to an occlusion of the foramen of Monro. This complication usually brings on pressure symptoms with some abruptness, with an increase of headache and possibly vomiting; and under these conditions a choked disk may become superimposed on the atrophic nerve head. Still, even this sequel cannot produce a neuroretinal edema if the nerves are completely enveloped in the tumor mass, for the sheath of Schwalbe can no longer be distended by the tense cerebrospinal fluid. A number of cases are cited in which, after operation, there was a restoration of vision in previously blind eyes—which leads to the conclusion that the amblyopia associated with an apparent primary atrophy more often represents a physiological block to light impulses than an actual destruction of the nerves.

Some degree of exophthalmos has been shown by almost all patients with tumor. It is rare in the absence of definite growth. Presumably, therefore, it is purely a local stasis phenomenon (cavernous sinus?).

Some distortion of the visual field was found in all but 2 of Dr. Cushing's 23 patients showing pronounced neighborhood symptoms. However, the supposed typical bitemporal hemianopsia with a vertical meridian which bisects the macula is conspicuously rare in the series. Indeed, in the 21 cases there are only 3 instances of fairly symmetrical bitemporal field defects, and it was fortuitous that the patients happened to be seen in exactly this stage of the process. Of the remaining 18 patients, 1 was blind on admission, doubtless after a bitemporal hemianopsia, and another was nearly so, though some vision returned in the nasal fields after the operation. Eleven of the patients were blind in one eye, the process having started as a bitemporal defect in 6 instances, as a homonymous defect in 4 and being uncertain in 2. One of the patients showed a typical, and another a fairly typical, homonymous hemianopsia.

Dr. Cushing continues:

> It becomes apparent from this brief summary, in the first place, that homonymous defects, or tendencies in this direction, are at least half as frequent as bitemporal ones. Indeed they are probably quite as frequent, for in a number of the patients who have been referred to us the diagnosis has been based solely on the existence of a bitemporal hemianopsia, and doubtless there are many in whom a homonymous defect, even though coupled with pallor of the disks, would have been regarded as equally significant. It is apparent, in the second place, that unilateral amblyopia may occur with but little if any perimetric deviation in the field of the opposite eye. Finally, and what is perhaps of greater clinical significance, mere tendencies toward temporal defects must be carefully looked for, particularly defects limited to the color peripheries, if one wishes the perimeter to serve in making a diagonsis before the time when crude finger tests suffice to demonstrate a complete hemianopsia. Heretofore perimetric investigations of these conditions have been confined largely to the observance of advancing lesions, and as the process is notably slow, often extending over years, the sequence of the changes is rarely observed.

OPHTHALMOSCOPIC EXAMINATION

The electric ophthalmoscope has converted what was formerly difficult and obscure into a procedure so simple that no modern practitioner hesitates to make his own examination in the ordinary light of room or ward, gaining thereby an early knowledge of conditions which were formerly thought to be the province of the specialist. It is obvious, however, that some special training is needed to discern the varied changes in the fundus and to interpret them.

It should not be necessary to describe the ophthalmoscope or the method of using it. The electric ophthalmoscope invented by Dr. Dennett, modified and improved by Dr. Marple, by whose name it is known, and made by E. B. Meyrowitz, is an instrument of precision with many refinements of technic, enabling one—by minute modifications of the light by means of the rheostat, by changes of focus of the lamp, by moving the cuff on the handle up and down, and especially by altering the correcting glass in the ophthalmoscope itself, so that different levels of the fundus may be studied and their elevations or depressions measured—to study the changes in the eyes exhaustively.

Another type is the De Zeng ophthalmoscope, less delicate in its adjustments, but a very serviceable instrument and less fragile.

The method should be practiced constantly and needs no elaboration here, but a few suggestions may be made: A 1 per cent. solution of homatropin may be used to dilate the pupils, with safety in most cases, but it will occasionally precipitate an attack of glaucoma, especially in elderly people. Before using it, then, it is wise to inquire for the prodromal symptoms and to test the tension with the fingers. It is prudent and considerate to follow the dilatation of the homatropin with a drop of a 1 per cent. solution of pilocarpin.

The amount of light used should be controlled by the rheostat. Fine distinctions of color are seen best with a moderate illumination, brighter light being reserved for the study of small details. The comfort of the patient and the saving of lamps are also reasons for avoiding too intense a light.

The ophthalmoscope should be used to study the condition of the transparent media. With a plus glass of 4 D. to 10 D., held at a short distance from the patient's eyes, traces of old vessels in the cornea, the sign of interstitial keratitis, or the circumscribed opacities of old phlyctenules, indications of constitutional conditions, syphilis and tuberculosis, may be seen and utilized by the careful diagnostician. The presence of cataract and of opacities in the vitreus may modify the appearance of the fundus; astigmatism also may cause a blurred outline of nerve and vessels which would be misleading if the cause were not recognized. Finally, the examination is not complete without a careful exploration of the periphery of the fundus for signs of retinitis and choroiditis, and the region of the macula lutea should be studied with as much care as the nerve itself.

CHOKED DISC

Etiology and Diagnosis.—Choked disc, or papilledema, is caused in part by increased intracranial pressure. There are undoubtedly other factors, but they are not definitely known. The terms optic neuritis, papillitis, and neuroretinitis apply to conditions associated with infections, toxemias, and inflammation, and, while in all of these conditions the appearances may be very similar to that of choked disc, as a rule the edema is more diffuse and the elevation of the disc less sharp. The terms neuritis and papillitis imply an inflammatory cause which is not known to exist in choked disc; therefore, it is well to discard them in the consideration of diseases dependent on intracranial pressure. No line can be drawn that will separate all cases of optic neuritis from choked disk. The same ophthalmoscopic picture may occur in nephritis, diabetes, syphilis, the infectious diseases, in meningitis, abscess of the brain, and otitis media. Less frequent causes are lead poisoning and anemia. The list of recorded causes is long and it is essential to exclude them in a doubtful case before deciding upon an operation for the relief of pressure, unless other symptoms are present and decisive.

Cases illustrating the difficulties of diagnosis, as well as a very complete review of the subject, may be found in "Neurologie des Auges" (4 Band, Zweite Halfte), Wilbrand and Sanger.

Uhthoff gives the following classification of the causes of choked disc in 204 cases:

	Cases
Brain tumor	134
Cerebral syphilis	27
Cerebral tuberculosis or meningitis	9
Cerebral abscess	7
Hydrocephalus	7
Meningitis	2
Cysticercus	2
Sinus thrombosis	2
Bone cicatrix of skull	1
Deformity of skull	3
Nephritis	3
Nephritis and lead poisoning	1
Anemia	2
Uncertain diagnosis	4

Since Von Graefe's classification, in 1860, a swelling of the nerve of 2 D. or more (2/3 mm.) has been called choked disc. Recently the name papilledema has been suggested as describing the earlier stage before the swelling has reached its fuller development.

The progress of brain surgery has made the earliest possible diagnosis of intracranial pressure desirable. Decompression has undoubtedly saved vision in many cases by preventing the development of choked disc. It is therefore most important to study the earliest changes, when the nerve fibers are still unimpaired by the pressure of the edema and atrophic changes have not begun. See treatment of Fractures of the Skull.

Course of Choked Disc.—The swelling of the nerve may be rapid, reaching its full development in a few weeks, or it may extend over a period of months or years, gradually passing into a stage of atrophy if decompression has not been done.

Any attempt to divide the process into stages is artificial, but the following classifications, modified by Cushing from that first given by Marcus Gunn, has value and is quoted with slight modifications from Dr. Cushing's second paper.

STAGE 1.—This shows some hyperemia of the disks, with haziness of the upper and lower margins where they are crossed by the main vessels. This haziness gradually spreads over and obscures the nasal half of the disk, the temporal edge remaining clear. There is some filling in of the physiologic cup, the lamina cribosa being obscured, and the veins are slightly full and sinuous. Visual acuity is not affected. A prompt restoration occurs after decompression.

STAGE 2.—The swelling of the papilla, now obscuring the temporal as well as the nasal margin, has become measurable, the physiologic cup is filled in, and there may be an extension of the edema to the surrounding retina. There is an outspoken stasis with tortuosity of the veins. There is apt to be a subjective lowering of acuity, but this may be absent even in the succeeding stage. Contraction of the field, especially for colors, may be present. Rapid return to the normal follows relief of pressure.

STAGE 3.—There is a further swelling of the papilla, which is now definitely prominent and spreads over a larger fundus area. The normal margins of the nerves are lost. The margin of the swollen nerve may be abrupt or may merge into the edematous retina which shows striations and hemorrhages. Visual acuity is usually reduced and the fields contracted, but normal relations are restored, and usually normal acuity, after adequate decompression.

STAGE 4.—The papilla becomes more prominent and, losing its reddish color, becomes opaque. Hemorrhages may be more numerous and larger, and exudates similar to those seen in nephritis may be present on the disk or in the surrounding retina. Many cases, however, especially those of slow onset, remain free from hemorrhages and exudate. There is new tissue formation, giving a fluffy appearance to the disc. Acuity of vision is considerably lowered. There may be transient amaurotic periods. There is further contraction of the field and colors may be seen only in large objects. Complete pressure relief such as may be afforded by tumor extirpation, or by adequate decompression in a case with symptoms of short duration, may lead to an almost total restoration of vision, but if the condition at this stage has been of long standing, and there is an excess of new tissue formation, there may be a further postoperative lowering of vision as the edema subsides.

According to De Schweinitz, "The attacks of temporary amaurosis, lasting from a few minutes to a few hours, followed by a restoration of the vision to that which existed prior to their occurrence, may be an early symptom, even preceding the choked disc."

STAGE 5.—There is a gradually decreasing vascularity of the papilla. Its surface becomes paler than normal and shows the fine, fluffy appearance due to new tissue formation, the contraction of which tends to produce a subsidence of the measurable swelling. This may disclose the shimmering atrophic disc as through a mist. The arteries tend to become of smaller caliber and the thickening of their perivascular lymph sheaths is apparent. This is the stage of atrophy with supposedly (Gunn) inevitable blindness. Acuity is reduced to the counting of fingers or less. There are frequent periods of temporary amaurosis. Colors are usually not seen, but small form fields, often requiring large, bright objects, may be plotted. These often show a tendency to a binasal hemianopsia with loss of central vision. Some vision may be preserved by operation.

Changes in Visual Field.—The close relation of choked disc to changes in the field of vision must be kept constantly in mind. Dr. Cushing associates the color interlacing, the blue within the red, with the early stages of choked disc, as has been stated in this article. It is probably not a reliable symptom, but it may be of value and should be looked for. Its detection is a simple step in the routine as described above.

In his second paper he says:

> "There have been ten cases of tumor which have shown color interlacing, either in the total absence of a choked disc or with a very incipient process observable in the eye grounds. As the reader will surmise, therefore, these represent cases in which localizing (irritative) symptoms have led to a precocious surgical intervention and consequently to the best operative results.
>
> "Thus, in these ten cases the tumor was enucleated in five instances, was exposed and considered irremovable in one, and was unlocalizable and not disclosed by the operation (decompression) in four. In all of them the normal color relations were restored after the operation."

The changes of the visual field which occur in connection with choked disc are dependent in part on the pressure of the edema and new formed connective tissue on the nerve fibers. The first change, not constant, is an enlargement of the blind spot. Then the periphery is narrowed. This is especially noticeable if the field is measured with a gray object or with blue as has been suggested. It means that the quantitative vision, or sensitiveness of the retina to a modified light stimulus, is impaired, and not that there is a loss of the specific blue perception. Later, as the connective tissue contracts, the red field suffers most. Sectors are lost or scotomas appear in the field.

Finally, as the contraction of the fibers progresses, the field narrows to the fixation point, colors are lost, and in a certain number of cases, as Cushing in his third paper states, the nasal fields are lost, showing that the uncrossed fibers to the temporal halves of the retina are interrupted by pressure of the dilated third ventricle, which forces the tracts or nerves against the rigid carotids. Dr. Cushing has noted this condition in 5 to 6 per cent. of his 300 cases. He says that it occurs as a late sequel of an advanced choked disk in the stage of recession of the edema; and a bilaterally symmetrical process, implying an equal degree of involvement of the 2 eyes, suggests, as a rule, a distant, often a cerebellar, lesion with secondary hydrocephalus.

Choked Disc and Brain Tumors.—Choked disc occurs in more than 80 per cent. of all cases of cerebral tumor. The elevation of the disc at its height averages 4.5 D.

In cerebellar tumors the percentage is higher (88 per cent., Uhthoff, 100 per cent., L. Paton) and the height of the swollen nerve is 1 D. to 2 D. greater.

Choked disc may be present with tumors in any region; its existence gives no evidence as to the size or nature of the growth. The localization of the growth is often difficult and depends on other symptoms which need not be discussed here, as they would require a review of the neurological field far beyond the scope of this article. In general, it may be said that tumors involving the surface of the anterior frontal and the motor convolutions are less apt to be associated with choked disc.

Tumors of the deeper parts of the frontal lobes may produce characteristic symptoms by pressure on the chiasm and the optic nerves: hemianopsia, atrophy preceded by retrobulbar neuritis with central scotoma, and with choked disc on the opposite side, as has been well shown by Foster Kennedy.

Tumors of the temporal and occipital lobes are accompanied by choked disc more frequently, the latter associated with crossed homonymous hemianopsia, which, however, must be differentiated from the hemianopsia due to disease of tract or chiasm. The Wilbrand pupil reaction and prism test may be mentioned as means of distinguishing tract hemianopsia from that due to lesions of the occipital lobe.

A symptom of disease of the optic centers is shimmering, sparks, or even visual hallucinations, in the blind field. It should be remembered that a tumor of the parietal or temporal lobes may cause partial hemianopsia by pressure on the optic radiations.

Choked disc is most frequent in tumors of the cerebellum, next of the basal ganglia, and occurs least often when the pons, medulla, and corpus callosum are involved.

That choked disc appears first, and is more advanced or more pronounced on the side of the tumor in a majority of cases, is probably true. Recent experimental work, as well as clinical observation, supports this view.

Treatment.—Operations undertaken for the relief of intracranial pressure are either radical or palliative. As Dr. Frazier says, it is a well-known fact that the large majority of tumors, whether pretentorial or subtentorial, are inoperable. That is to say, the majority are either inaccessible, or impossible of localization, or of such a nature as to make their removal inconsistent with the maintenance of life. Dr. Frazier concludes that 75 per cent. to 80 per cent. are inoperable. Decompression is, therefore, the proper operation in a large majority of cases. It means, if done sufficiently early, preservation of vision and a relief from headache and vomiting, and it does not prevent the performance later of a radical operation for the removal of a tumor if the development of symptoms permits localization.

Summary.—What has been said may be summarized briefly as follows:

The existence of choked disc demands an immediate and thorough investigation. If it is not due to toxemia or to infection, the probability of increased intracranial pressure must be kept in mind, and the corroborative symptoms, headache, vertigo, and vomiting, as well as the symptoms referable to the other cranial nerves, must be studied.

The field of vision and the blind spot must be measured at frequent intervals, and at the first sign of loss of central or peripheral vision, decompression must be practiced without waiting for developments which might aid localization.

The prompt and adequate relief of intracranial pressure at an early stage of choked disc offers the best hope of preservation of vision as well as of relief from the distressing headache and vomiting, and this, in a majority of cases of cerebral tumor, is all that can be expected.

CHAPTER II

OPERATIONS ON THE EYE AND ITS APPENDAGES

John M. Wheeler

GENERAL CONSIDERATIONS

Whether an eye operation calls for general anesthesia or not, it is always wise for the patient to have free purgation before he is operated upon. Examination of the heart, lungs, and kidneys should be made, and the patient's general condition should never be lost sight of by the surgeon. Often it is important that diseased conditions which might give rise to coughing, sneezing, vomiting, hemorrhage, or lowered vitality should be remedied before a patient's eye is operated on. Any measure which will aid in putting the eye patient into the best possible physical condition before operation should be employed.

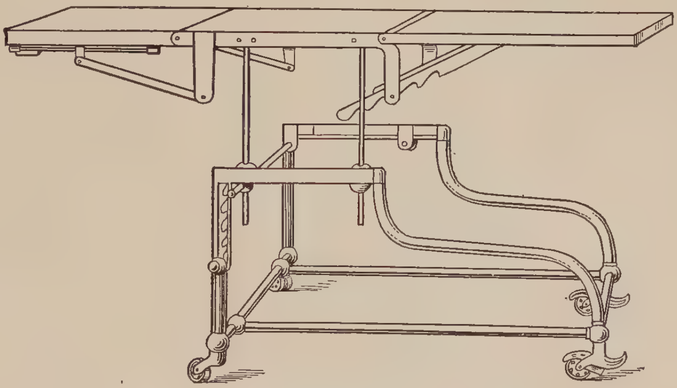


Fig. 1.—Ophthalmic Operating Table.

Before operating it may be necessary to combat an infection of the conjunctiva, cornea or lacrimal sac. In preparing a patient with a diseased lacrimal sac for operation on the eyeball, usually it is unwise to employ such conservative treatment as irrigation and probing, but rather complete extirpation of the sac should be performed at once in order to render the eye free from the danger of infection which an inflamed sac offers.

The local preparation of the patient is usually simple. The eyelids, eyebrows and skin of the face about the eye should be thoroughly cleansed with soap and water applied with cotton sponges, followed by sponging and irrigation with 1:5,000 bichlorid solution. Finally the eye is irrigated freely with boric acid solution 2 to 4 per cent. A simple bulb irrigator such as is shown in Figure 2 answers as well as anything for this purpose. Usually it is not necessary to cut the eyelashes or shave the eyebrow. Sterile towels or a special face covering with an aperture to expose the operative field should be applied.

The operator renders his hands aseptic and wears a sterile cap and gown. Some ophthalmic surgeons choose to wear a covering for the mouth and nose, but few are accustomed to wearing gloves for eye surgery.

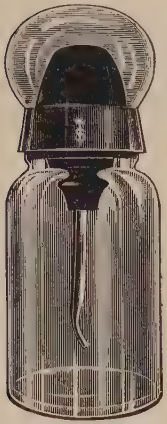


FIG. 2.—IRRIGATION BOTTLE AND BULB.

A good overhead daylight is best for most eye work, as it is less taxing on both the patient and the operator than a brilliant artificial light; but for a few operations, such as discission of the anterior or posterior capsule of the lens and extirpation of the lacrimal sac, a penetrating condensed artificial illumination is called for.

The patient's head should be at such a height as to enable the operator to work comfortably in the standing posture. Some ophthalmic surgeons prefer to sit while operating, but one who has accustomed himself to the standing position is conscious of the restriction in movement which the sitting position entails. Anything which interferes with freedom of movement on the part of the surgeon should be avoided.

For most operations the surgeon can work to better advantage at the patient's head, and not at one side, although some skilled operators choose to stand or sit on the right or left of the patient.

ANESTHESIA FOR EYE OPERATIONS

Local anesthesia is used for the greater part of eye operating. Whether a general or local anesthetic should be used must be left usually to the discretion of the operator. In many operations the choice may be left with the patient. Speaking broadly, it may be said that *general anesthesia* is called for in such operations as enucleation of the eyeball or any of its modifications, in operations on the orbit, in operations for acute glaucoma or on eyes painful and sensitive from any cause, in all operations on babies and young children, and in operations on the eyeball in very nervous and hypersensitive adults. There are no conditions of the eye which contra-indicate the administration of general anesthesia. The choice of anesthetic and the manner of administration are matters of preference on the part of the surgeon and anesthetist, but it might be said that ether anesthesia is in general use for eye patients. In some eye operations it is inconvenient for the surgeon to have an inhaler over the patient's nose, and it is better to have the anesthetic given through a tube.

Local anesthesia is best accomplished by the use of cocain hydrochlorate.

For instillation a 4 per cent. solution is satisfactory. It may be combined with adrenalin 1 : 1,000, which is an adjuvant of cocain, and a valuable hemostatic in eye work. For anesthetizing the cornea, 2 or 3 instillations of 4 per cent. cocain 2 minutes apart suffice. For the deeper structures of the eyeball, such as the iris and muscles, it is well to allow 15 minutes and to instill 4 per cent. cocain every 3 minutes during this period. The eyes should be kept closed during this process, and the patient should not be allowed to rub his eyes, or the epithelium of the cornea may be loosened and abraded. Holocain 1 or 2 per cent., or alypin 3 to 5 per cent. may be used for local anesthesia, and both have an advantage under certain circumstances, in that they do not

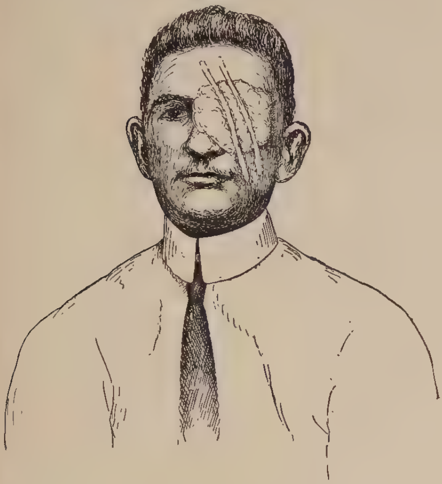


FIG. 3.—DRESSING HELD IN PLACE BY SILK ISINGLASS PLASTER.

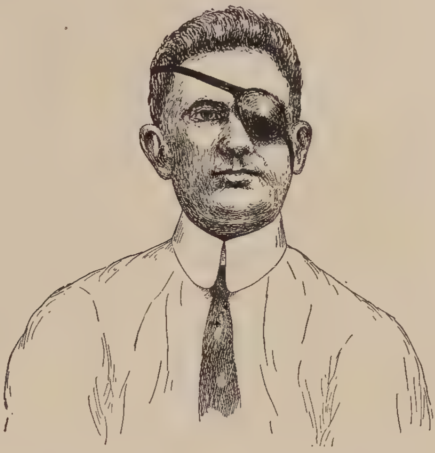


FIG. 4.—EYE PATCH WITHOUT DRESSING.

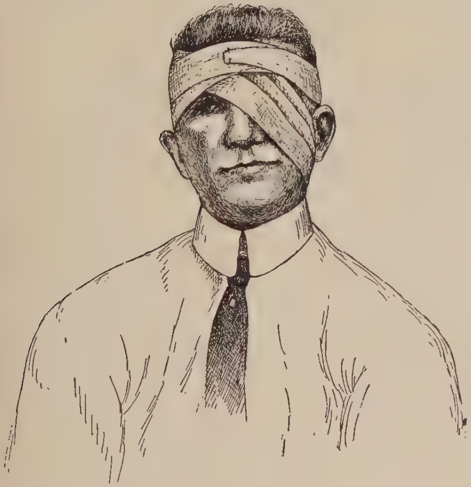


FIG. 5.—MONOCULAR DRESSING AND BANDAGE.

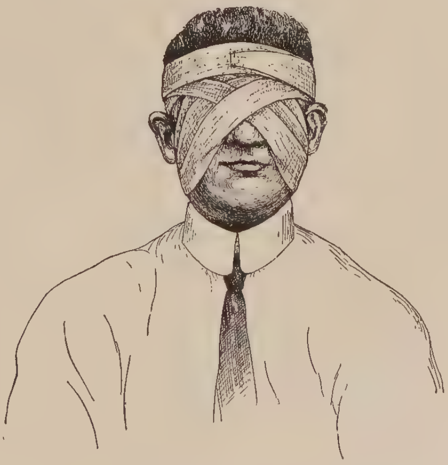


FIG. 6.—BINOCULAR DRESSING AND BANDAGE.

dilate the pupil; but their anesthetic effect is not as certain as that of cocain.

For injection in the tissues of the lids or under the conjunctiva, a solution made up of 4 per cent. cocain 1 part, 1:1,000 adrenalin 1 part, and sterile water or normal salt solution 2 parts is satisfactory. Novocain 1 per cent. is used for injection by some operators. It has the advantage of being less toxic than cocain.

OPERATIONS ON THE EYEBALL

SURGICAL ANATOMY OF THE EYEBALL

The eyeball is an imperfect sphere. Its shape has caused it to be likened to a globe and it is generally referred to by ophthalmologists as "the globe." Carrying out the comparison, it is said to have an *anterior pole* in the center of the cornea and a *posterior pole* at a point diametrically opposite. The meridians pass through these imaginary poles, and the *equator* encircles the eyeball midway between the anterior and posterior poles. The diameter of the eyeball is nearly an inch. To be more exact, the anteroposterior diameter usually is 24 mm. and the other diameters are about 23 mm. The reason for the greater anteroposterior measurement is found in the fact that the cornea has a greater curvature than the rest of the eyeball. The eyeball has three principal coats; the outer is tough and protective; the middle is essentially vascular; and the inner is the nervous or perceptive layer.

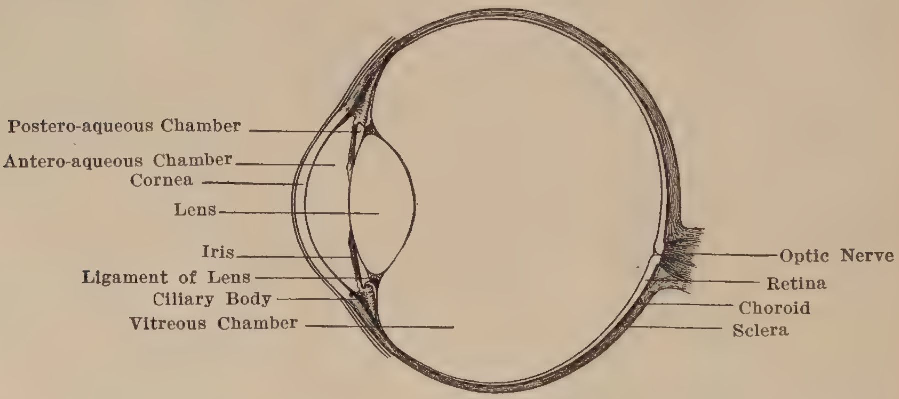


FIG. 7.—CROSS-SECTION OF EYEBALL.

Outer Layer of the Eyeball.—The outer coat is fibrous and is made up of the cornea and sclera.

The *cornea* is the clear, transparent tissue which forms the anterior 1/6 of the globe. It is about 1 mm. in thickness near its margin and somewhat thinner toward the center. At the border it is slightly overlapped by the sclera, and for this reason it is said to be set in the sclera as a "watch crystal in a watch." The diameter of the cornea is slightly less than ½ in. (diameter vertically 11 mm., and horizontally 12 mm.). There are 5 layers in the cornea: (1) the external epithelial layer, (2) the anterior elastic membrane (Bowman's membrane), (3) the substance proper of the cornea, (4) the posterior elastic membrane (Descemet's membrane), and (5) the endothelial lining. The epithelial layer on the surface of the cornea is very easily detached from Bowman's membrane so that denudation from injury is rather a common occurrence. Fortunately no scar results from injury to the epithelial layer, but any injury or ulcerative process which penetrates deeper than this layer leaves scar tissue. Opacification attends the formation of scar tissue in the cornea, and opacities in the pupillary area result in permanent impairment of vision. There are no blood vessels in the cornea but nutriment is provided by a free lymphatic circulation in the substance proper.

The *sclera,* or sclerotic, is the tough, white posterior 5/6 of the outer coat of the eyeball. It is perforated a little to the nasal side of the posterior pole, where the optic nerve joins the globe and the nerve fibers pass into the retina. It is at this point that the eyeball is weakest, and it is here that the wall gives way in case of increased intra-ocular tension, and the glaucomatous "cup" is formed. The junction of the cornea and the sclera is called the *limbus.* It should be kept clearly in mind that the cornea fits into the sclera, as it were, so that the sclera overlaps. This anatomical fact is of importance in making incisions into the anterior chamber. The angle between the cornea and iris is reached by entering slightly behind the superficial line of junction of cornea and sclera. The 4 recti muscles are attached to the sclera 5 to 8 mm. behind the limbus, and the 2 obliques to the sclera behind the equator.

Middle Layer of the Eyeball.—This is made up of the choroid, the ciliary body, and the iris.

The *choroid* is made up largely of blood vessels, capillaries, and pigment. From a surgical point of view, this structure is not of importance, except for the possibility of severe intra-ocular hemorrhage from a large choroidal vessel. Occasionally, after sudden reduction of tension during operation for cataract or glaucoma, a hemorrhage into the vitreous chamber occurs, which results in loss of the eye.

The *ciliary body* encircles the inner surface of the sclera behind the corneoscleral junction. It is to this structure that the ligament of the lens is attached, and it is through the contraction of its muscle fibers that the shape of the lens is changed and accommodation is regulated. Surgically the ciliary body is important, because serious injury to it results in the destruction of the eye and endangers the fellow eye through the liability of sympathetic inflammation. It is for this reason that the portion of the eyeball approximately from 2 mm. to 8 mm. behind the margin of the cornea is called the "danger zone."

The *iris* is the incomplete curtain which lies in the aqueous chamber. The opening near the center of it is called the pupil, and the inner border is called the pupillary margin. The outer border is attached to the ciliary body and is called the ciliary margin. The pupillary margin rests on the anterior surface of the lens and lies in a plane further forward than that of the ciliary margin. The iris has a rich blood supply and sometimes bleeds freely when incised. One of the most common eye operations is the removal of a portion of the iris. The operation is called iridectomy and the resultant opening is called a coloboma.

Inner Layer of the Eyeball.—The *retina* forms the innermost coat of the eyeball. Detachment of the retina sometimes follows operation or other traumatism. Many operations have been suggested for the cure of retinal detachment, but all have resulted in failure.

The *conjunctiva* is a mucous membrane which covers the eyeball from the cornea nearly back to the equator and is reflected to the posterior surface of the eyelids, thus forming the upper and lower conjunctival culs de sac. *Tenon's capsule* is a layer of fascial tissue in which the eyeball moves. It lies in contact with the sclera.

The *lens* is a clear biconvex body, which is held in position behind the iris by the attachment of its suspensory ligament to the ciliary body. When the ligament is torn the lens is said to be dislocated. The posterior surface of the lens is more convex than the anterior surface. The lens has an epithelial covering called its *capsule.* The portion on the anterior surface is called the anterior capsule and that on the posterior surface is called the posterior capsule. When a person is about 25 years of age the lens develops a hard center called the *nucleus.* This becomes larger and harder as the years of age increase. The softer portion of the lens between nucleus and capsule is called the cortex. Opacity of the lens or any portion of it is termed *cataract.*

The *aqueous chamber* of the eye is in front of the lens. As its name implies, the consistency and appearance of aqueous are like those of water. The *anterior chamber* is in front of the iris, and varies considerably in depth in different individuals, both normally and in disease. The *posterior chamber* is behind the iris and contains much less aqueous than the anterior.

The *vitreous chamber* is behind the lens and within the retina. It is filled with a transparent substance, about the consistency of the white of an egg, called the *vitreous* or vitreous body. This is surrounded by a transparent homogeneous membrane known as the *hyaloid membrane.* It is due to the presence of this very thin membrane that loss of vitreous is prevented when the ligament of the lens is injured in such operations as extraction of cataract and iridectomy.

OPERATIONS ON THE CORNEA

Corneal Ulcer

Ulceration of the cornea may result in serious impairment of vision through scar formation, or even in complete loss of the eye through panophthalmitis. Corneal ulceration always should be regarded seriously, and in the case of virulent infection it is sometimes wise to resort to the cautery, curet, or knife.

Cauterization.—The eye must be thoroughly anesthetized. The surgeon may employ either the electrocautery with platinum tip, or a probe of platinum or silver heated in the flame of an alcohol lamp. The electrocautery is more satisfactory, as the degree of heat can be controlled.

A speculum should be used, and the eye held with fixation forceps. Any ulcer which carries an infection of such virulence as to call for the use of the actual cautery deserves most thorough cauterization. The applications should be gently made, but sufficient in number to cover the entire margin and base of the ulcer. There is no pain connected with cauterization, provided the eye has been thoroughly cocainized. Bichlorid vaselin (1:5,000) should be used in abundance, and a dressing and bandage applied. The eye should be kept anointed under a dressing for several days.

Saemisch Incision of Cornea.—In certain progressive ulcers of the cornea, with considerable exudate in the anterior chamber (hypopyon), the cornea is incised after the method of Saemisch to drain the corneal tissue and to allow the escape and drainage of the exudate. This operation is performed less frequently than formerly, as preference is given to the less radical forms of treatment. Usually the procedure cannot be done under local anesthesia with safety to the lens, as it is accompanied with such pain that the patient cannot be relied upon to control the pressure from spasm of his eyelids. Primary gas or ether anesthesia is sufficient.

A speculum is introduced and the eye is held by grasping with fixation forceps the conjunctiva and subconjunctival tissues a little to the nasal side of the cornea. A cataract knife is then made to enter the cornea a little outside the temporal margin of the ulcerated area and the point carried across the anterior chamber to emerge near the nasal margin of the ulcer in the clear cornea. Thus an incision is made through the diseased cornea, and the aqueous and exudate are allowed to escape from the anterior chamber. After irrigation of the wound and anterior chamber with boric acid or 1:5,000 bichlorid solution, bichlorid vaselin, dressing and bandage are applied. Drainage may be maintained for several days by opening the corneal wound with a fine instrument such as a spatula. The patient experiences relief from pain through the lowering of intra-ocular tension.

After the Saemisch incision the iris becomes incarcerated in the wound, and the area of ulceration becomes a dense white scar (leukoma), which can be tattooed after all signs of irritation have passed away.

Tattooing of the Cornea.—The operation of tattooing is performed almost exclusively as a cosmetic measure. Following extensive ulceration of the cornea, dense scar tissue remains and offers the appearance of a white spot in contrast to the colored iris in the background. The disfigurement is especially conspicuous if it rests in the pupillary area, and the white spot is contrasted with the black pupil of the fellow eye. Tattooing will change the white area into a black one, and greatly improve the appearance of the eye and the individual. From an economic standpoint, this change may be an important one for the patient.

INSTRUMENTS.—Speculum, fixation forceps, spatula, tattooing needle. Several different models of needles are in use. The operator may use an instrument with a row of fine needles, or a clump of needles. I prefer a single, firm, grooved needle with which definitely directed punctures may be made.

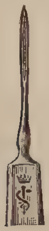


Fig. 8.—Tattooing Needle.

India ink is commonly used to produce a black spot. The ink is scraped from a cake and baked to sterilize. Then it is thoroughly broken up and worked into a thin paste by rubbing with sterile water in a sterilized dish. In the attempt to match the color of the patient's iris in scar tissue lying outside the pupillary area, mixtures of colored pigment (sepia, ultramarine, vermilion) are occasionally used.

OPERATION.—After anesthetizing the cornea with cocain solution, the speculum is inserted and the eye is irrigated with boric acid solution. The eye is steadied with the fixation forceps, and with a spatula a little of the ink paste is put on the corneal scar and worked into the cicatricial tissue with gentle strokes of the tattooing needle. The punctures should be directed diagonally and should work the ink well into the tissues, or the pigment will not remain. If the cornea is thin, care must be taken not to perforate into the aqueous chamber. Of course this operation should not be performed on an inflamed or irritated eye, or on one with a thin and bulging cornea. The procedure may be repeated as many times as necessary to produce the desired result, providing sufficient time elapses for the eye to become quiet before each repetition. The eye should be kept under dressing and bandage for a few days after tattooing.

Paracentesis of the Cornea

When it is advisable to reduce the tension of an eye temporarily, paracentesis with escape of aqueous may be employed. Iritis with tension, acute glaucoma, traumatic cataract with swelling of the lens, corneal ulceration, and secondary glaucoma are such conditions as may call for puncturing of the cornea. The permanent reduction of tension usually cannot be secured by this operation but it may sometimes be performed advantageously to assist healing, to relieve pain or to put an eye in better condition for further operation.

ANESTHESIA.—Unless the eye is in an extremely sensitive condition, paracentesis may be performed under local anesthesia.

INSTRUMENTS.—Speculum, fixation forceps, Graefe knife or keratome.

OPERATION.—Control the eye by fixation of the conjunctiva in the horizontal meridian near the cornea, and enter the anterior chamber with a Graefe knife by puncturing the cornea near its margin on the temporal side. Care should be taken not to allow the point of the knife to pass in front of the pupillary area, as the lens might be injured. Rotate the handle of the knife slightly and allow the aqueous to escape slowly. A sudden gush of aqueous might produce an intra-ocular hemorrhage. After the aqueous chamber is emptied, withdraw the knife and apply a dressing and bandage, which should be kept on for a day or two. Instead of the Graefe knife, a keratome may be used. If it is the preference of the surgeon to use a keratome, the incision in the cornea may be made above instead of at the side.

OPERATIONS ON THE CONJUNCTIVA

SUBCONJUNCTIVAL INJECTIONS

Many different solutions have been injected under the conjunctiva for anesthetic and therapeutic purposes.

More complete anesthesia of the deeper structures of the eyeball, particularly the iris, is obtained by subconjunctival injection than by instillation. A solution of cocain 4 per cent. and adrenalin 1:1,000 equal parts is satisfactory for anesthetic purposes. For their therapeutic effect, solutions of sodium chlorid, bichlorid of mercury, cyanid of mercury, dionin and other drugs have been injected in many ocular diseases, such as corneal ulcer, interstitial keratitis, iritis, choroiditis and detachment of the retina. There is considerable difference of opinion as to the therapeutic value of this form of treatment.

The technic of the injection is simple. First anesthetize the conjunctiva by the instillation of cocain. Then introduce a speculum, or hold the lids open with the fingers. Pick up a small fold of the conjunctiva with a pair of fine tissue forceps and pierce it close to the forceps with the hypodermic needle, injecting a few drops of the solution. The important cautions are not to pick up in the forceps subconjunctival tissue, and not to get into the adherent tissues near the cornea, but several millimeters away from it. In making a series of injections it is well not to make them repeatedly in the same place, but to vary the position.

PTERYGIUM

Pterygium (*wing*) is a triangular fold of thickened conjunctiva which is caused by exposure to the wind, sun, and dust. It is more common on the nasal side of the cornea than on the temporal side, but may appear on both sides. The apex is referred to as the head; a small adjacent portion is called the neck; and the wing-like expansion is termed the body. As growth takes place, the head advances from the corneal margin toward the center of the cornea, causing a cosmetic disfigurement and endangering the sight.

The cure lies in excision or transplantation, and the operation of McReynolds gives the most satisfactory results. Very few recurrences follow the proper performance of this procedure. In the *Ophthalmoscope* of March, 1914, McReynolds described the operation as follows:

"(1) Grasp completely the neck of the pterygium with strong but narrow fixation forceps. (2) Pass a Graefe knife through the constriction and as close to the globe as possible, and then, with the cutting edge turned toward the cornea, shave off every particle of the growth smoothly from the cornea. (3) With the fixation forceps still hold the pterygium, and with slender straight scissors divide the conjunctiva and subconjunctival tissue along the lower margin of the pterygium, commencing at its neck and extending toward the canthus a distance of one-fourth to one-half of an inch. (4) Still hold the pterygium with the forceps and separate the body of the growth from the sclera with any small non-cutting instrument. (5) Now separate well from the sclera the conjunctiva lying below the oblique incision made with the scissors. (6) Take black silk thread armed at each end with small curved needles and carry both of these needles through the apex of the pterygium from within outward and separated

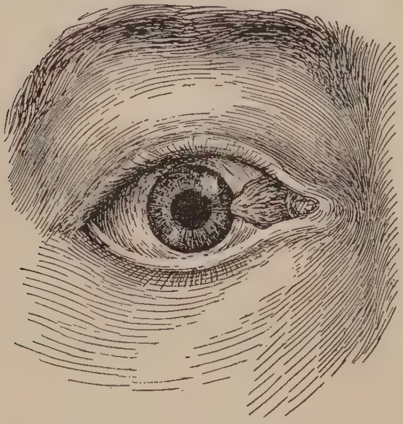


Fig. 9.—Pterygium of Right Eye.

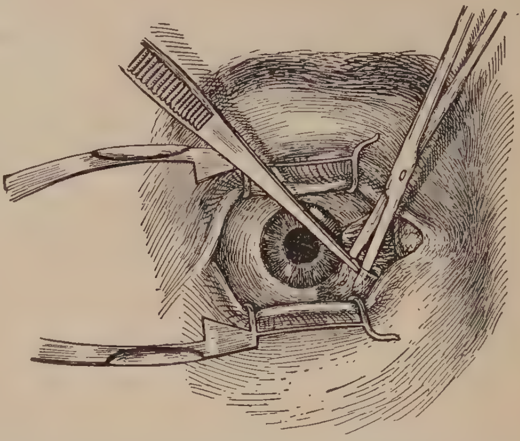


Fig. 10.—McReynold's Transplantation Operation for Pterygium. Undermining conjunctiva.

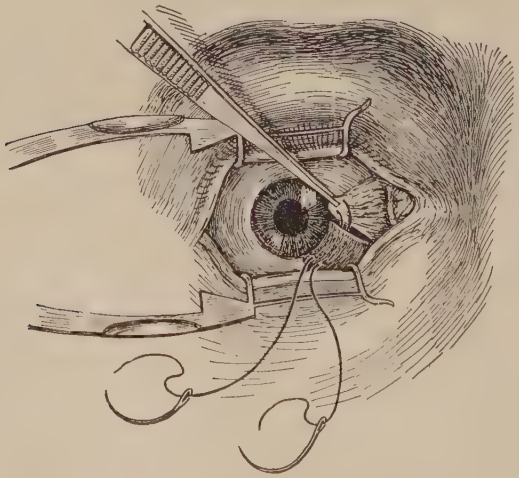


Fig. 11.—Transplantation of Pterygium, Showing Position of Burying Suture Before Tying.

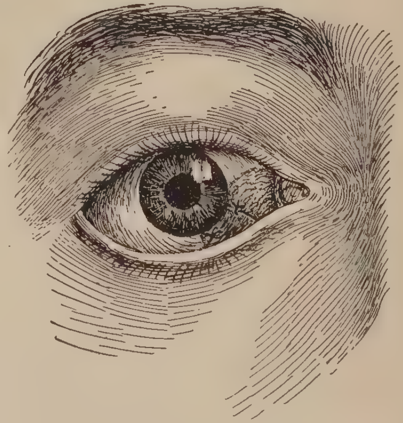


Fig. 12.—Transplantation of Pterygium. Operation Completed.

from each other by a sufficient amount of the growth to secure a firm hold. (7) Then carry these needles downward beneath the loosened conjunctiva lying below the oblique incision made by the scissors. The needles, after passing in parallel directions beneath the loosened lower segment of the conjunctiva until they reach the region of the lower fornix, should then emerge from beneath the conjunctiva at a distance of about one-eighth of an inch from each other. (8) Now, with the forceps lift up the loosened lower segment of the conjunctiva and gently exert traction upon the free ends of the threads which have emerged from below, and the pterygium will slide beneath the loosened lower segment of the conjunctiva, and the threads may then be tightened and the surplus portions of the thread cut off, leaving enough to facilitate the removal of the threads after proper union has occurred.

"It is very important that no incision should be made along the upper border of the pterygium, because it would gape and leave a denuded space when downward traction is made upon the pterygium. On the contrary, the elasticity of the conjunctiva is such that when this downward traction is exerted upon the head of the pterygium the conjunctiva becomes thinned out, and smoothly applied to the sclera corresponding to the former site of the body of the growth, and the margin of the conjunctiva coincides accurately with the sclerocorneal junction. Thus, when the operation is completed and the speculum removed, no stitch is seen, because it is hidden by the lower lid; the only denuded area is on the cornea. The former site of the body of the pterygium is covered by a thin and comparatively non-vascular conjunctiva, and what blood vessels remain are directed downward and not horizontally, and hence do not tend to encroach again upon the cornea. In fact, the whole vascular activity is concentrated beneath the lower lid, where it is not only removed from view, but protected from the irritating influences of dust and exposure, and the process of atrophy naturally and surely follows. In the meantime, the corneal wound heals quickly and the thin conjunctival tissue becomes closely adherent to the sclera in the palpebral opening. After a few days the single stitch can be removed, and the old pterygium will be found firmly adherent to the sclera and hidden beneath the loosened lower segment of the conjunctiva.

"If the head of the growth is very large, so that it covers something like a third of the cornea, and if the body is also very thick and fleshy, it may be best to dissect away the head from the cornea with a sharp knife, and then remove with scissors a part of the head and a part of the subconjunctival portion of the body of the growth, and then deal with the rest of the pterygium, according to the method already described.

"Practically, the only discomfort to be apprehended will be in the first few hours succeeding the operation, and this can be effectually relieved by cold applications and the occasional instillation of a weak anesthetic solution. A light bandage should be worn for a few days and the patient is instructed to avoid as far as possible those conditions which have a tendency to favor the development primarily of this affection.

"The conjunctiva remains red for a few weeks after the operation, but the redness gradually disappears, and a small scar on the cornea marking the position of the head of the pterygium is all that ultimately remains as the result of the growth."

OPERATIONS ON THE IRIS

Iridectomy

Except in cases of optical iridectomy and in iridectomy for liberation of the iris from wounds, the operation is performed in the upper part of the iris, so as to have the resulting coloboma covered by the upper lid.

INSTRUMENTS.—Speculum, fixation forceps, keratome, iris forceps, iris scissors, and spatula.

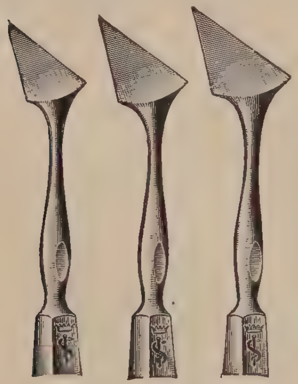


FIG. 13.—KERATOMES, 3 SIZES.

ANESTHESIA.—Except in cases of acute glaucoma, unless the eye is in a tender condition, local cocain anesthesia suffices. Five instillations of a solution of 4 per cent. cocain hydrochlorate 3 minutes apart will give almost complete anesthesia of the iris.

OPERATION.—After introducing the speculum, take the fixation forceps in the left hand and the keratome in the right and fix the eyeball in the median line about 1 mm. below the cornea, grasping the conjunctival and subconjunctival tissues. The patient should look well down toward his feet, assisted by the fixation forceps.

INCISION.—Pierce the conjunctiva and sclera with the point of the keratome about 1 mm. from the corneoscleral junction and enter the aqueous chamber through the iris angle. As soon as the point of the instrument can be seen

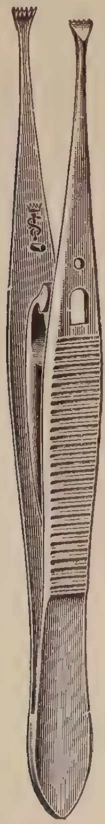


FIG. 14.—FIXATION FORCEPS FOR HOLDING EYEBALL.

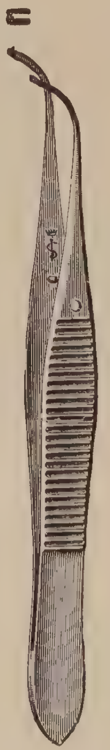


FIG. 15.—IRIS FORCEPS.

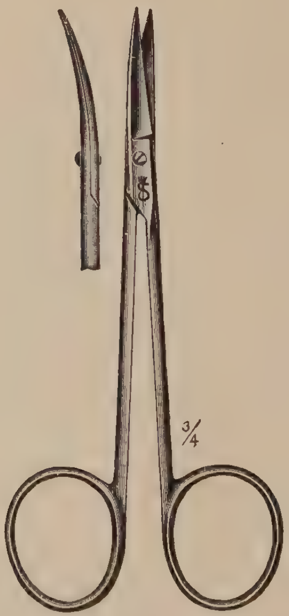


FIG. 16.—IRIS SCISSORS.

in the anterior chamber, direct it toward the center of the cornea and carry it in until the incision is the desired length. If the point of the keratome should catch in the iris and should be carried forward, the iris would be torn from the ciliary body. To avoid this, withdraw the keratome, cutting laterally with either edge of the instrument as it is brought out of the anterior chamber. If the wound is still too small it may be enlarged with a pair of small curved scissors. As the keratome is withdrawn sometimes the iris prolapses through the wound, rushing out with the aqueous.

Iridectomy.—The assistant hands the operator the iris forceps and scissors and takes the fixation forceps to control the position of the eye while the operator is performing the iridectomy. Grasp the iris with the points of the iris forceps about 1 mm. from the pupillary margin. Hold the blades of the scissors in contact with the globe, straddling the iris forceps. Pull the iris out until the pigment at the pupillary margin can be seen. Make traction on the iris, cutting it off quickly while pressing gently on the globe with the blades of the scissors. If the scissors are not in contact with the globe when the cut is made, the iridectomy will fail to extend to the ciliary margin of the iris.

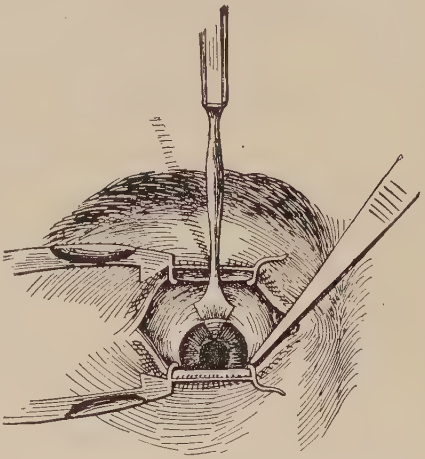


Fig. 17.—Keratome Incision for Iridectomy.

Adjustment of the Iris.—Enter the point of the spatula in the wound in a downward and inward direction at the nasal end of the wound, and downward and outward for the temporal end of the wound and see that the iris is perfectly free. Do not stroke the iris within the anterior chamber for fear of injuring the lens. Ordinarily, after iridectomy, the resiliency of the iris tissue carries it back into the anterior chamber with almost no manipulation. This is not the case after cataract extraction. Unless there is glaucoma, put a drop of atropin 1 per cent. in the eye. The eye should be kept under dressing and bandage for about one week.

OPERATIONS ON THE LENS

High Myopia

In properly selected cases, removal of the lens in high myopia gives gratifying results. The operation should be performed only on eyes with myopia of 15 diopters or over, and with reasonably healthy interiors. Macular lesions destroying central vision contra-indicate the removal of the lens. The operation is usually performed on patients under 40 years of age.

OPERATION.—First a thorough needling of the anterior capsule and cortex should be performed as described under Needling of Anterior Capsule (page 30). Swelling and opacification of the lens result from the needling. Acute glaucoma with severe pain is anticipated within a few days and usually the lens matter must be removed, preferably by linear extraction (page 31). This second step is deferred as long as possible so as to allow the cortex of the lens to become cataractous. With the eye in a condition of acute glaucoma, extraction under local anesthesia may be very painful, so it is usually wise to administer a general anesthetic. After the extraction a little soft lens matter always remains. When this has been absorbed a discission of the secondary membrane should be performed, providing the secondary membrane materially interferes with the vision. Then the patient must be equipped with glasses for distant and near sight.

CATARACT

Cataract is opacity of the lens or its capsule or both. *Soft cataract* occurs in the young before the nucleus of the lens is formed, or while it is small. *Hard cataract* occurs in elderly people after the nucleus is well formed. *Congenital cataract* occurs in the new-born, and often is incomplete and usually non-progressive. *Senile cataract* is found in elderly people, as its name implies, and is progressive. *Traumatic cataract* results from injury, and often is associated with wounds of the cornea and iris. It is more common in the young than in the old. *Secondary cataract* is the membrane which remains after removal of the lens. For the purposes of the surgeon most operative cataracts can be classed as soft, hard or secondary.

Soft Cataract.—This condition is dealt with by needling of the anterior capsule, by linear extraction, or both, followed by discission of the secondary cataract if necessary. Following needling of the anterior capsule partial or complete absorption of the cortex of the lens occurs in the aqueous. The operation may be repeated as many times as necessary for complete absorption, or linear extraction of the cortex may be performed. Absorption of the lens is a slow process, and removal by linear extraction should be performed when the element of time figures prominently, and in eyes which develop acute glaucoma following needling.

NEEDLING OF THE ANTERIOR CAPSULE.—INSTRUMENTS. — Speculum, fixation forceps, small needle knife.

ANESTHESIA.—Local anesthesia is sufficient in all cases except babies.

OPERATION.—The pupil should be under full atropin dilatation. Introduce the speculum and illuminate the eye with condensed artificial light. Fix the eyeball near the limbus at a point opposite the place of entry of the knife needle. For right-handed operators, the most convenient point for entering the needle is in the upper temporal quadrant of the cornea in the right eye and the upper nasal quadrant in the left eye, a millimeter or two from the limbus. Some operators prefer to enter through the conjunctiva near the corneal margin, but one cannot work to as good mechanical advantage from this point of entry. With the knife needle, puncture the anterior capsule and carry the incision into the lens cortex and across the anterior capsule, taking care not to puncture the posterior capsule, and so go in the vitreous. A second or third incision may be made at the discretion of the operator. Withdraw the knife quickly with its cutting edge in the same direction as in entering the cornea. As the knife is withdrawn, usually the aqueous is lost through the wound. Apply dressing and bandage to the operated eye only. In babies a starched bandage should be used. The dressing may be left off in 2 or 3 days, but the eye should be kept under atropin until the lens matter is absorbed.

LINEAR EXTRACTION.—INSTRUMENTS.—Speculum, fixation forceps, keratome, cystotome, spatula. Normal saline irrigation.

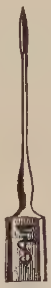


FIG. 18. — KNIFE NEEDLE.

OPERATION.—The pupil must be dilated *ad maximum.* Fix the eye in the median line about 1 mm. below the cornea. Have the patient look gently down and enter the angular keratome in the upper part of the cornea about 3 mm. from the limbus, carrying the point of the keratome through the anterior capsule and into the cortex of the lens, taking care not to allow the point of the instrument to go through into the vitreous. After withdrawing the keratome, enter the cystotome through the corneal wound and make several cuts in the anterior capsule of the lens, at the same time stirring up the anterior cortex. Then irrigate until the soft lens matter ceases to come out through the wound. If considerable lens matter remains, use the spatula and stroke the lens substance carefully into the pupillary area, and irrigate again. The use of the spatula and irrigation may be repeated until all of the lens matter is out or until the remaining lens matter refuses to move. Instil atropin 1 per cent. Dressing and bandage should be worn for a few days. The patient may sit up the day after operation. If a little lens matter remains following the operation, the eye is kept under the influence of atropin until it is absorbed. If the posterior capsule interferes materially with the vision, this may be incised after all the lens cortex has been absorbed and the eye is perfectly quiet.

Extraction of Hard Cataract.—Hard cataracts develop in elderly persons, and for this reason are called senile cataracts. In extraction, the operator attempts to deliver the nucleus and cortex of the opaque lens without injuring its posterior capsule, and without disturbance or loss of vitreous. (An exception to this is found in the delivery of the lens in its capsule as practiced by a few eye surgeons.) Senile cataract may be extracted without iridectomy, in which case the operation is referred to as *"simple extraction"*; or a portion of the iris may be removed and the operation is called "extraction with iridectomy" or *"combined extraction."* In immature cataract and complicated cataract, and cataract in a patient's only eye, and in certain other selected cases, iridectomy is performed 2 weeks or more previous to removal of the lens. The first operation is referred to as *"preliminary iridectomy,"* and the second as *"extraction after iridectomy."* Some ophthalmic surgeons perform preliminary iridectomy as a routine in hard cataract.

Simple extraction offers the advantage of better cosmetic effect than extraction with iridectomy, and the important disadvantage of increased liability of prolapse of the iris after the operation. Extraction with iridectomy or after iridectomy is performed much more frequently than the simple operation because of the security which the surgeon has that the iris will not prolapse into the wound after operation, and because of the comparative ease of delivering the lens through the opening accomplished by iridectomy. Preliminary iridectomy renders extraction of the lens easier and safer.

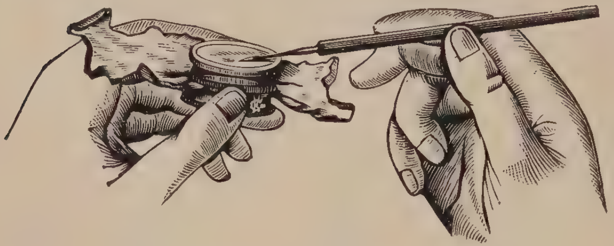


FIG. 19.—TEST DRUM, HARD RUBBER, WITH FINE KID, FOR TESTING THE POINTS OF INSTRUMENTS.

EXTRACTION WITH IRIDECTOMY.—INSTRUMENTS.—Speculum, fixation forceps, cataract knife, iris forceps, iris scissors, cystotome, capsule forceps, lens spoon, spatula, irrigator, normal salt solution.

ANESTHESIA.—Anesthesia may be secured by 5 or 6 instillations of cocain 4 per cent. 3 minutes apart. Adrenalin 1:1,000 may be put in the eye with the last two cocain instillations to enhance the anesthetic action of the cocain and to control the hemorrhage. If a patient is unable to relax his eyelids, general anesthesia should be given.

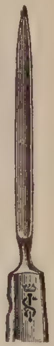


FIG. 20.—CATARACT KNIFE.

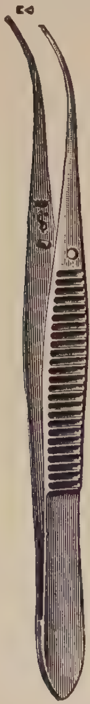


FIG. 21.—IRIS FORCEPS FOR CATARACT EXTRACTION.

OPERATION.—If the eyelashes are long and liable to be in the way of the knife, they may be cut close with the scissors near the outer canthus.

After irrigation with boric acid solution, introduce the speculum, and irrigate again. Grasp the conjunctiva and episcleral tissue in the vertical meridian just below the cornea, or to the nasal side either near the cornea or at the insertion of the internal rectus so as to include the tendon. Most surgeons prefer to fix below the cornea. The *section* (Fig. 26) should be made through the upper 2/5 of the corneoscleral junction, and a small conjunctival flap should be made. If the operator stands at the head of the table, the knife is held in the right hand for the right eye, or in the left hand for the left eye. With the eye directed well downward the incision should be made with free sliding motions. To make a perfect section for cataract extraction, without injuring the iris, requires training and skill. After completing this incision remove the fixation forceps, and lay the small conjunctival flap back on the cornea. Some surgeons remove the speculum at this point in the operation.

If *iridectomy* is to be performed, grasp the upper part of the iris near the pupillary margin with the iris forceps and lift it through the wound. When the pupillary margin presents, straddle the fold of iris with the scissors, and with both blades in contact with the globe cut it off.

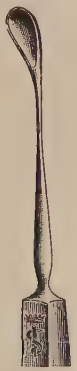


FIG. 23.—LENS SPOON.

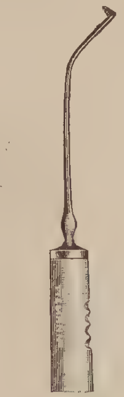


FIG. 22.—CYSTOTOME FOR INCISING ANTERIOR CAPSULE OF LENS.

Now with the cystotome or capsule forceps, or both, make a free *opening in the anterior capsule,* taking care not to catch the iris with the instrument and not to injure the ligament of the lens. If the speculum has not already been removed, it is well to take it out at this time.

To accomplish *delivery of the lens,* let the patient look gently downward, while the upper lid is supported with a lid retractor or with the finger, and with the edges of the spoon make gentle pressure toward the center of the globe in the lower part of the cornea. This tilts the lens and makes it present in the wound. When the lens starts to come out, the pressure toward the center of the eyeball should be released and the lower margin of the lens should be carefully followed up by very gentle pressure on the cornea.

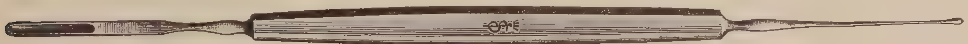


FIG. 24.—IRIS SPATULA AND PROBE COMBINED.

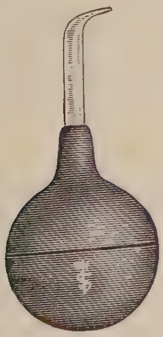


FIG. 25.—ANTERIOR CHAMBER IRRIGATOR.

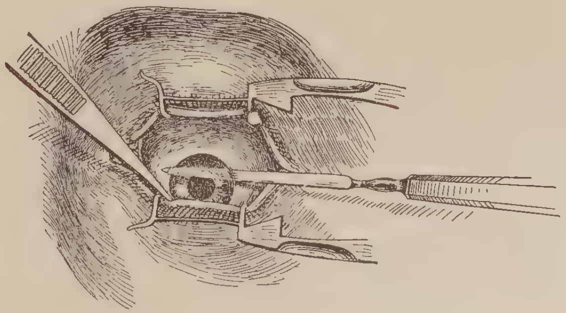


FIG. 26.—CATARACT EXTRACTION, LEFT EYE. MAKING THE SECTION. Puncture and counterpuncture have been made.

For *irrigation of the anterior chamber* body temperature salt solution or sterile water may be used. A simple irrigator such as is shown in Figure 25 is best. The stream should be gentle and under perfect control, and the tip of the irrigator should not be introduced beyond the lips of the wound. When all bits of lens cortex have been washed out irrigation should cease.

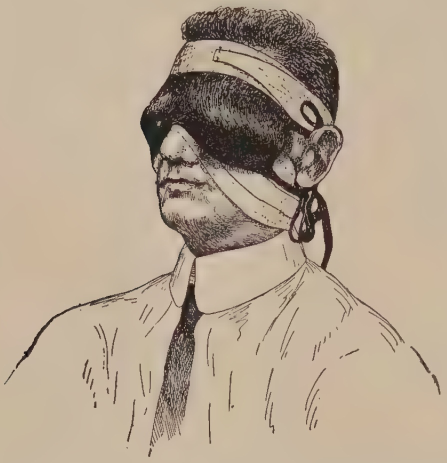


Fig. 27.—Binocular Dressing and Bandage with Ring Cataract Mask.

Replacement of the iris is accomplished by carefully directed strokes of the spatula. It is essential for prompt healing after operation that the flaps of iris be left entirely free from the wound; otherwise iridocyclitis is apt to result.

After laying the conjunctival flap in position, a drop of 1 per cent. atropin sulphate solution is instilled unless the operation has been a simple extraction, in which case the pupil should not be dilated until the wound is closed. This usually would be at the first dressing. The eyes should be gently closed and kept closed. Both eyes should be covered with dressings and bandage, and a good protective mask, such as the Ring mask, should be put on.

Except for the omission of iridectomy, simple extraction and extraction after iridectomy are performed in the same way as extraction with iridectomy.

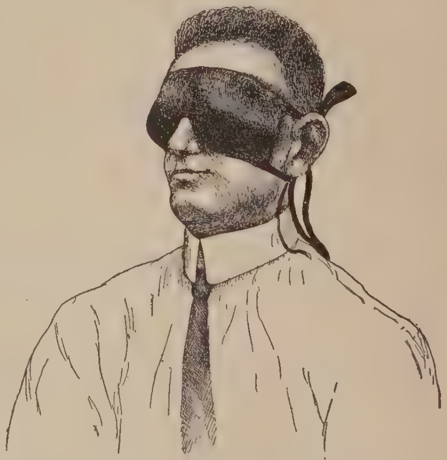


Fig. 28.—Ring Cataract Mask Without Dressing.

The after-treatment must vary somewhat in different patients. If the patient is comfortable, the first dressing may be done 2 days after operation. Daily change of dressings after the second day is customary. Unless there should be a rise in intra-ocular tension, atropin should be instilled at each dressing and as long afterward as particles of lens matter remain, or until the eye is perfectly quiet. The unoperated eye may be uncovered usually 3 or 4 days after operation, and the patient may sit up. At the end of a week all dressing may be removed, but the mask should remain over the operated eye for protection a week or two longer. If the secondary membrane prevents the patient from getting good vision, this should be incised (page 35). In a healthy eye cataract extraction should yield normal or nearly normal sight with the proper glasses. It might be added that the proper extraction of cataract requires extraordinary skill, contrary to a rather general belief in and out of the medical profession.

EXTRACTION IN CAPSULE.—This operation is commonly known as the "Smith operation." It has been done extensively in India, but has not been generally adopted in other countries. In brief, the operation consists in the removal of the cataractous lens in its capsule by tearing it from its attachment to the ciliary body through delicate and dexterous manipulation with an instrument resembling a large squint hook. Another method is to grasp the anterior capsule with a special forceps and remove the entire lens within its capsule. The chief advantages of extraction in capsule are that no secondary membrane is left and that immature cataracts can be extracted as well as mature. The important disadvantage is that it is attended with more danger to the eye than the classical extraction of the lens from its capsule.

Secondary Cataract.—Following every case of cataract extraction, unless the lens has been removed in capsule, a secondary cataract remains. That is, if the extraction has been successfully performed the posterior capsule remains intact, together with some fragments of the anterior capsule, and in some cases a little soft lens matter which has become incarcerated between the posterior capsule and the fragments of the anterior capsule. This membrane is usually referred to as a secondary cataract. **After extraction of the lens, such cases as have decided impairment of the visual acuity on account of the secondary cataract should have a discission of this membrane. For a general rule, this operation should not be performed on a patient having a vision of 20/40 with the proper correcting lens, as there is, of course, a possibility of carrying infection into the eye.** Three principal operations for secondary cataract are needling, De Wecker's scissors operation, and division with a discission knife. Whatever operation is chosen, the pupil should be fully dilated with atropin and the operation should be performed under condensed artificial light.

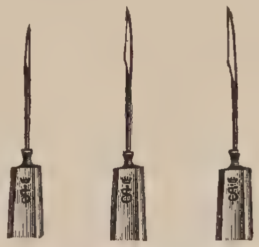


FIG. 29.—ZIEGLER KNIFE NEEDLES, 3 SIZES.

NEEDLING.—Perhaps the best of the operations for secondary cataract performed with a needle knife is that advocated by Ziegler of Philadelphia.

INSTRUMENTS.—Speculum, fixation forceps and Ziegler knife-needle.

OPERATION.—The instrument enters the cornea near the limbus above and penetrates the posterior capsule behind the iris at two points, in the lower temporal and lower nasal quadrants. Two cuts are made in the membrane which meet in or near the median line. These incisions should be accomplished by a sawing motion and should make a V-shaped flap in the posterior capsule (Fig. 30). Usually the flap of posterior membrane does not stay in the pupillary area. If it does, the membrane should be pushed aside into the vitreous with the point of the instrument.

DE WECKER OPERATION.—Instruments.—Speculum, fixation forceps, Agnew keratome, De Wecker's scissors and spatula.

Operation.—Fix the eye in the median line just below the cornea. Have the patient look gently down. Enter the keratome in the cornea about 2 mm. from the upper limit. If an iridectomy has been performed, as is usually the case, carry the point of the instrument through the secondary cataract in the coloboma. If no iridectomy has been performed, enter the pupil at the margin above. By tilting the handle of the keratome downward, away from the operator, the wound in the secondary cataract is opened. This should be done in order to allow the vitreous to come into the aqueous chamber. This manœuver prevents the sudden collapse of the anterior chamber when the keratome is removed. Sudden loss of the anterior chamber is to be avoided, for with the outrush of the aqueous the pupil contracts and the iris lies against the cornea, causing difficulty in the completion of the operation. Next enter De Wecker's scissors (closed) through the corneal wound, and allow one blade to pass into the vitreous chamber behind the posterior capsule and the other blade in front of the capsule. Make 2 cuts, one in a downward and outward direction, and the other in a downward and inward direction. More than 2 cuts can be made at the discretion of the operator. A small amount of vitreous is lost in this operation, and it may be wiped away from the corneal wound with a sponge or cut away with the scissors. By running the spatula along the corneal incision, the operator assures himself that the iris is free from capsule. The scissors operation should be done only in those cases in which there is an unusually heavy membrane to cut, or in cases in which it is necessary to perform an iridotomy. Dressing and bandage should be worn for a few days.

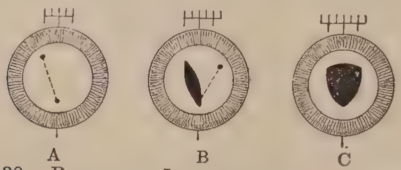


Fig. 30.—Plan of Incisions for Ziegler's Needling Operation for Secondary Cataract.

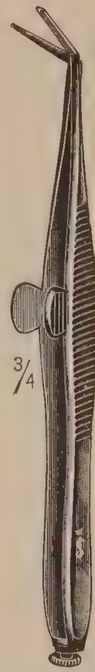


Fig. 31.—De Wecker's Scissors.

DISCISSION.—A single incision in the secondary membrane is sufficient in almost all cases of secondary cataract, providing it passes through the pupillary area and is of sufficient length. The incision should be carried across nearly the entire width of the secondary cataract. The operation should be performed either with a very narrow Graefe knife or with the author's discission knife. The blade of the latter instrument (Fig. 32) is 20 mm. long and tapers evenly to a point.

Instruments.—Speculum, fixation forceps and discission knife.

Operation.—The incision in the secondary cataract should cut the heaviest bands in the membrane and should be carried into the coloboma if there is one. With the fixation forceps grasp the eyeball below the cornea and enter the corneal tissue 2 mm. from the limbus above. Pass the point of the instrument carefully behind the iris, ready to enter the vitreous chamber through the secondary membrane. Sweep the point of the knife into the vitreous and cut clear across the membrane with a single sliding motion. In sliding the knife in and out of the eye, constant gentle pressure should be made away from the cutting edge of the knife so as not to enlarge the corneal incision, and the cornea should be used as a fulcrum. The handle of the knife is carried through a complex motion in which it is tilted away from the operator while it is entering and emerging from the vitreous chamber without any break. By this technic, a clean incision is made across the membrane before the flap has had time to relax. After the knife is withdrawn, the edges of the cut separate, and in almost every case a sufficiently large opening results with almost no traumatism to the eye. The eye should be kept under a dressing for 2 days.

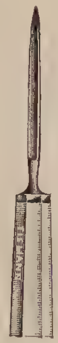


Fig. 32.—Wheeler's Discission Knife for Secondary Cataract.

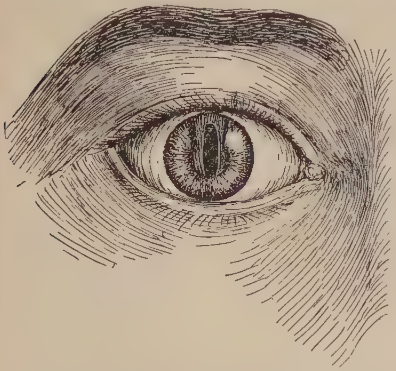


Fig. 33.—Discission for Secondary Cataract, Showing Opening in Membrane.

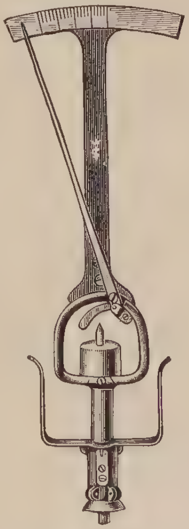


Fig. 34.—Schiötz's Tonometer for Measuring Intra-ocular Tension.

Glaucoma

In a normal eye the tension is between 15 and 25 mm. of mercury as measured by the tonometer. The term glaucoma indicates an increased intra-ocular tension. Glaucoma may be acute or chronic. It may be primary, or secondary to some other disease of the eye such as iritis or an intra-ocular growth. Uncontrolled increased intra-ocular tension may lead to atrophy of the optic nerve and blindness.

Acute Glaucoma.—Whenever it is possible this condition is controlled by the use of myotics, as operation endangers the eye through the possibility of an intra-ocular hemorrhage from the sudden reduction of the tension or injury to the lens which may lead to formation of cataract—a serious complication.

It is quite generally agreed that iridectomy is the operation of preference for this condition (page 27). Whenever it is possible, general anesthesia should be administered, as any operative procedure on an eye suffering from acute glaucoma is extremely painful under local anesthesia. In performing iridectomy for glaucoma, the surgeon should be sure to include the ciliary margin of the iris with a view to opening up the filtration angle. Trephining in *acute* glaucoma is advocated by Col. R. H. Elliott, and is practiced with success by some ophthalmic surgeons.

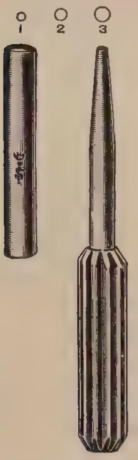


Fig. 35.—Stephenson's Trephine.

Chronic Glaucoma.—Many operations have been proposed for the relief of this condition, but most of them have been abandoned because they have not given consistently good results. Iridectomy (page 27) and trephining as proposed by Elliott in 1909 are the operations usually performed for the relief of this condition.

TREPHINING.—In this operation a large thin flap of conjunctiva is dissected up from the underlying tissues and the dissection is carried to the margin of the cornea and a little beyond if possible. With a trephine of about 1½ mm. in diameter a fistulous opening is made into the anterior chamber and a portion of the iris is removed so that it will not prolapse into the wound and plug the opening. By this operation an attempt is made to establish a permanent opening between the aqueous chamber and the subconjunctival lymph channels through which the aqueous drains and so maintains a reduction in the tension to normal.

The adoption of the Elliott operation has been rapid and quite general. If properly performed, it reduces tension to normal in a high percentage of chronic glaucoma cases. In fact, excessive reduction of tension sometimes results. Late infection has been reported in several cases. A number of years must elapse before it is time to pass final judgment on this promising and interesting operative procedure.

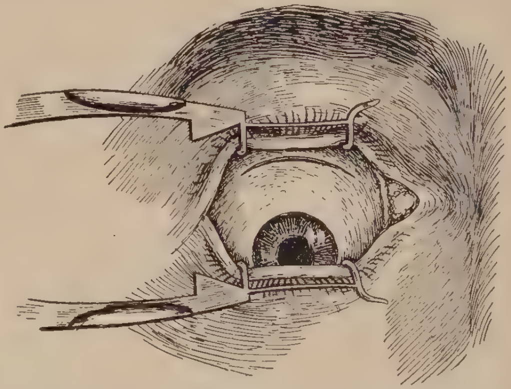


Fig. 36.—Corneoclearal Trephining for Glaucoma. Incision in conjunctiva.

Glaucoma from Old Iritis.—In certain cases of iritis, the pupillary margin of the iris becomes adherent to the anterior surface of the lens, and thus the passage of the aqueous from the posterior chamber to the anterior chamber is prevented. The iris bulges forward and a glaucomatous attack may occur from the interference with the drainage. Iridectomy should be performed to establish free communication between the aqueous chambers.

Absolute Glaucoma.—In neglected cases sometimes the eye becomes stony hard and the sight is entirely lost and the eye is a constant source of pain to the patient. This condition, referred to as absolute glaucoma, calls for enucleation of the eyeball, if iridectomy or trephining fails to give relief.

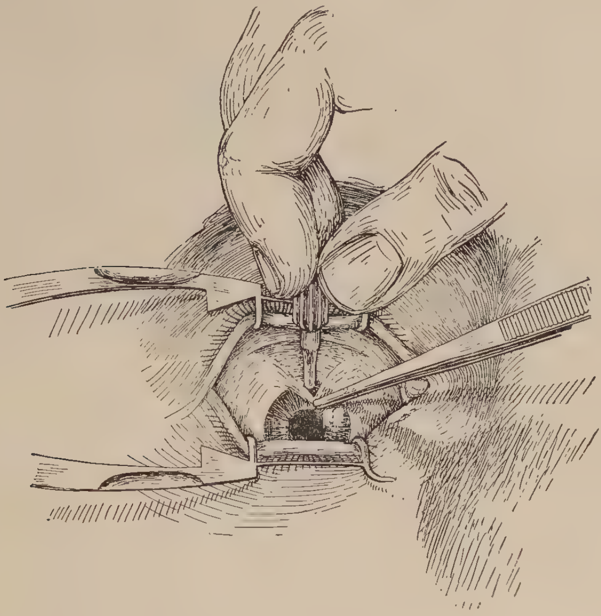


Fig. 37.—Trephining for Glaucoma. Conjunctiva held to expose corneoscleral junction. Trephine in position.

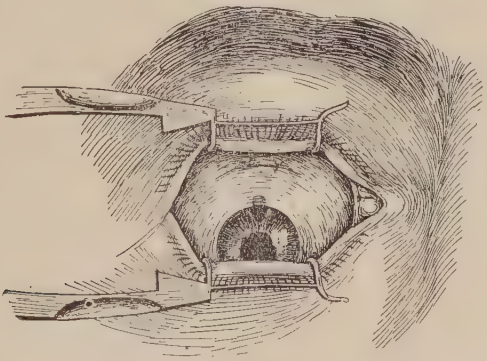


Fig. 38.—Trephining for Glaucoma. Operation completed.

At the time of operation for glaucoma in one eye, a myotic should be instilled in the other eye to guard against an acute attack.

Strabismus

Strabismus or squint may be either convergent or divergent, depending upon whether the squinting eye turns in or out. Convergence is more common than divergence, especially in children. The vision of the deviating eye usually becomes seriously impaired.

In most cases the problem that the surgeon has to solve in dealing with squint is a cosmetic one. A more or less blind eye which turns in or turns out is presented to the surgeon to be made to appear straight. This means that usually strabismus operations are performed for the sake of appearance only. To accomplish the straightening of an eye, the surgeon takes advantage of the possibility of weakening a rectus muscle by tenotomy, or of strengthening an opposing muscle by advancement of its insertion or by the resection of a portion of it.

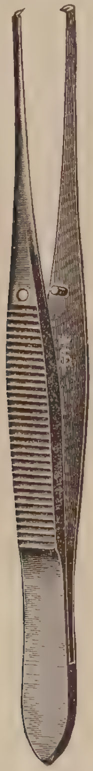


Fig. 39. — Mouse-tooth Forceps for Squint Operation.

There are many different methods of accomplishing muscle-shortening. In *advancement* the tendon is cut and the insertion is carried forward from its normal position toward the cornea. There are many variations in technic, but in all of the advancement procedures the aim is to increase the power of the comparatively weak muscle. The operation easiest and safest to perform and surest in effect and giving the best cosmetic results, is the Reese resection. This operation is performed almost to the exclusion of other muscle shortening operations at the New York Eye and Ear Infirmary.

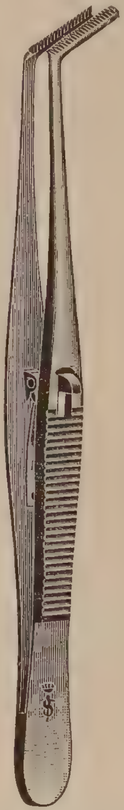


Fig. 40. — Reese Muscle Forceps.

Reese Resection.—INSTRUMENTS.—The instruments used are speculum, mouse-tooth forceps, straight scissors, curved scissors, plain forceps, squint hook, Reese muscle forceps, needle-holder, curved needles, double-armed suture of No. 3 braided silk (English), two No. 5 twisted silk sutures.

ANESTHESIA.—It is better to perform this operation under local anesthesia if it is feasible, as it is impossible for the operator to judge of the effect produced when the patient is under general anesthesia. But most strabismus cases are children, and a general anesthetic may be given if necessary. For local anesthesia, cocain should be instilled every 3 minutes during a period of 15 minutes and adrenalin 2 or 3 times during the 3 minutes just previous to the start of the operation. The adrenalin should be given whether the operation is performed under local or general anesthesia.

OPERATION.—Have the patient look intently in such a direction as will expose the muscle to be operated upon. Make a straight vertical incision in the conjunctiva along the insertion of the tendon or slightly behind the insertion (Fig. 41). The middle of this incision is 6 to 8 mm. from the cornea and in length should be equal to the diameter of the cornea or a little longer. In making the incision care should be taken not to cut through the tendon of the muscle about to be resected.

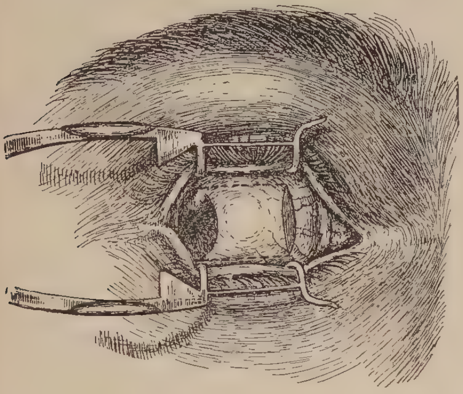


FIG. 41.—RESECTION OF INTERNAL RECTUS MUSCLE OF RIGHT EYE FOR DIVERGENT STRABISMUS. Primary incision of conjunctiva.

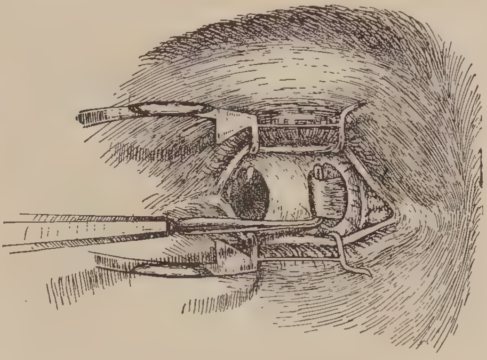


FIG. 42.—RESECTION OF INTERNAL RECTUS. Muscle held on hook for dissection.

At the upper and lower ends of the wound grasp the episcleral tissue and cut it through to the sclera with the scissors. This is an important step in the operation. Pass the strabismus hook through one of the openings just made, either above or below the tendon and take the muscle on the hook. The assistant holds the muscle taut with the squint hook while the surgeon carefully dissects up the conjunctiva freely from the muscle, and trims away the fascial

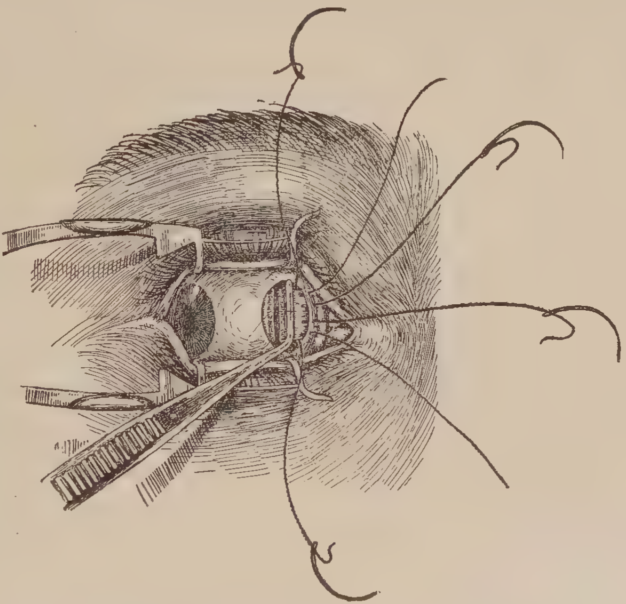


FIG. 43.—RESECTION OF INTERNAL RECTUS. Sutures have been introduced through muscle and lateral flap of conjunctiva.

tissues from the upper and lower margins of the tendon. One blade of the Reese muscle forceps is then passed under the muscle in place of the hook and the forceps is clamped on the tendon about 3 mm. from its insertion. The surgeon should see that the tendon is spread out before clamping. The muscle is cut off a millimeter or two from the globe so as to leave a stump to which the resected muscle is to be attached. The muscle is dissected entirely from the tissues that surround it.

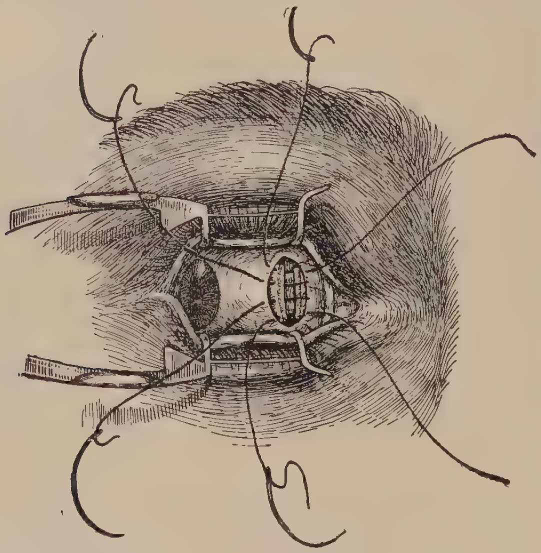


FIG. 44.—RESECTION OF INTERNAL RECTUS. Sutures are ready to tie.

Introduce the double-armed center suture so as to loop the muscle and conjunctiva, entering the needles about 2 mm. apart on the side of the muscle next to the eyeball and picking up the margin of the posterior conjunctival flap. The two lateral sutures should be introduced from the opposite direction; that is, through the conjunctiva first, and then through the muscle near the upper and lower borders. Put the large center suture through the stump first. To accomplish this, pick up the stump of the tendon with a pair of forceps and, entering the needles in the angle between the stump and sclera, carry the sutures through the stump and through the margin of the overlying conjunctiva. The upper and lower lateral sutures are passed through the tendon stump and conjunctiva in the same way and then all three of the sutures are tied. Thus the cut end of the muscle is brought to the original position of insertion, and the conjunctival wound is closed without additional sutures. Reese recommends that the lateral sutures be allowed to remain about a week, and the heavy center suture from 10 days to 2 weeks. The dressing and bandage are worn for about 1 week. In paralytic squint the resection may have to be repeated on the same muscle. There seems to be no objection to resecting the same muscle a number of times.

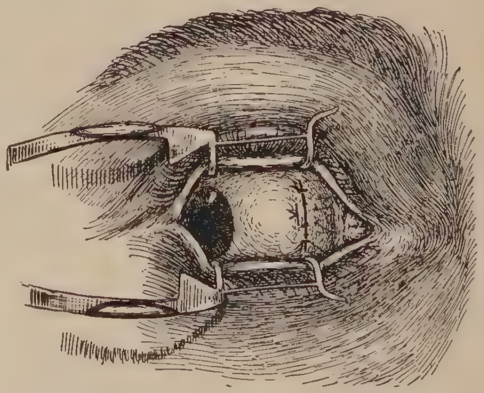


FIG. 45.—RESECTION OF INTERNAL RECTUS. Sutures have been tied and wound closed.

Tenotomy.—Tenotomy may be done either alone or in combination with resection or advancement. It may be complete or partial. In almost every case of divergent strabismus operated on complete tenotomy of the external rectus should be done in combination with resection of the internal rectus, as it is necessary to get a slight overcorrection (5 to 10°) in operating for divergence. In the case of the internal rectus, tenotomy must be performed guardedly, especially in growing children, as complete severing of the internal rectus tendon gives uncertain results; and limitation of motility of the eyeball and disfiguring divergence may be the outcome.

ANESTHESIA.—Cocain and adrenalin usually suffice, and the operator prefers local anesthesia, as he can judge better as to the effect produced at any step of the straightening process. The pain in this operation comes from the pulling on the muscle, so this must be avoided as much as possible.

INSTRUMENTS.—Mouse-tooth forceps, small curved scissors, such as Stevens scissors, strabismus hook, needle-holder and No. 5 twisted silk sutures.

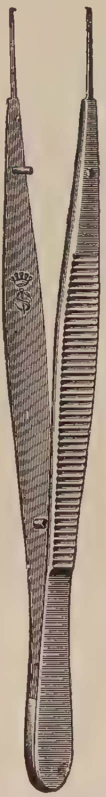


FIG. 46. — MOUSE-TOOTH FORCEPS FOR TENOTOMY.

OPERATION.—Cause the patient to look in such a direction as to expose the insertion of the muscle to be cut. Grasp the conjunctiva with mouse-tooth forceps and make an incision along the insertion of the muscle. Dissect up the conjunctiva from the muscle and in case of the internal rectus dissect up the semilunar fold and caruncle freely. Grasp the tendon near its insertion with tooth forceps and cut it through at the center of its insertion. Introduce the hook into the opening thus made, and lift either the upper or lower half of the tendon gently off from the globe. Then tuck the conjunctiva over the end of the hook and have the assistant hold it out of the way and cut toward the border of the muscle. Now lift the other half of the muscle on the hook and cut in the same way. By this method the operator is enabled to graduate his tenotomy accurately. Suture the conjunctival incision, taking care not to pick up the tendon. It is advisable to avoid sinking of the caruncle with a view to getting the best cosmetic effect. So in tenotomizing the internal rectus, it is important not only to dissect up the semilunar fold and the caruncle from the tendon, but also to use great care, in suturing, to draw the semilunar fold well forward, overlapping the conjunctiva if necessary in order to obtain

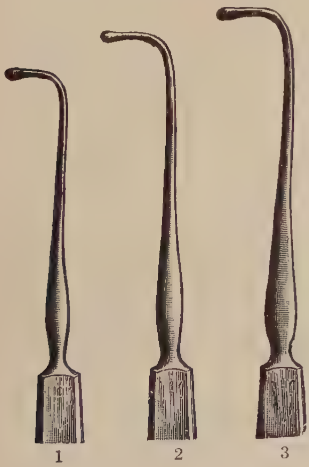


FIG. 47.—STRABISMUS HOOKS, 3 SIZES.

the best cosmetic effect. If the sutures do not fall out they may be removed in 4 or 5 days after the operation.

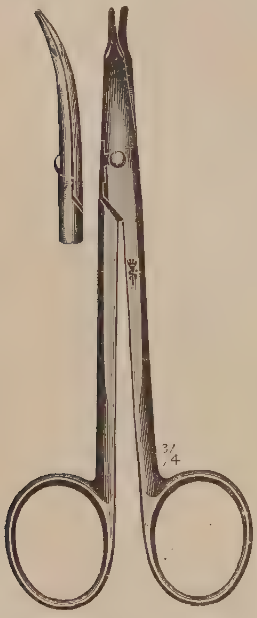


Fig. 48.—Stevens' Tenotomy Scissors.

If a *complete tenotomy* is to be performed, the insertion may be cut straight through from one border to the other. To accomplish this, after making the conjunctival incision, cut through the episcleral tissue and introduce a squint hook under the tendon and lift it away from the eyeball slightly. Then pass one blade of a straight scissors behind the tendon and cut it completely off at its insertion (Fig. 49). Approximation of the conjunctiva completes the operation.

INJURIES TO THE EYEBALL

Small superficial wounds of the cornea and conjunctiva usually need nothing more than antisepsis and dressing. Abrasion of the cornea is painful and may justify an analgesic. Absolute rest of the eye under dressing and bandage favors healing. In superficial wounds involving the conjunctiva, fine silk sutures may be introduced if the wound margins do not lie in good apposition.

Deep wounds of the cornea are liable to be complicated by injury to the iris with prolapse of this structure or by injury to the lens (cataract), or by injury to the neighboring sclera and ciliary body. There is room for considerable variation in these wounds, and oftentimes refinement of surgical judgment is called for. A simple penetrating wound of the cornea usually is best treated by atropin, and antisepsis obtained by a solution such as argyrol 25-50 per cent., or by an ointment such as bichlorid vaselin 1:5,000 to 1:3,000, and dressing with bandage. If the iris is prolapsed, free iridectomy should be performed as soon as possible to liberate it from the wound. In the case of a wound several days old, the iris may be adherent to the margin of the corneal wound, and should be carefully dissected free with a fine spatula or probe before attempting to cut the prolapsed iris off. In freeing any case of prolapsed iris, traction should be made on the prolapsed tissue with the iris forceps and the scissors

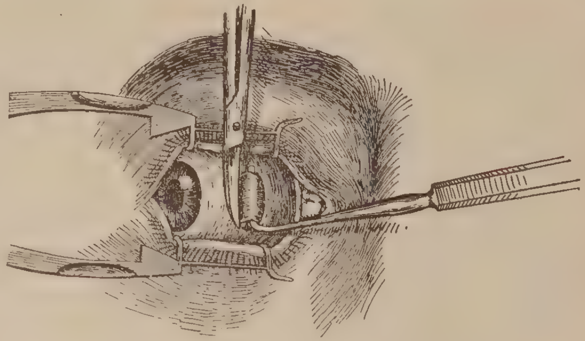


Fig. 49.—Performing Complete Tenotomy.

blades should be held close to the cornea when the cut is made. If a traumatic cataract exists it may be wise to attempt to extract as much of the lens matter as possible through the corneal wound by using saline irrigation and the spatula. Oftentimes, however, it is better to leave the lens alone, and let it take care of itself, with the possibility of extracting at a later date if necessary.

If a wound extends into the *ciliary body* so as to injure it seriously, the prognosis for the eye is bad. Probably the injured eye will be lost, and the fellow eye will be endangered. An eye sustaining such an injury should be enucleated at once to save the patient from pain, loss of time and especially danger of loss of the fellow eye through sympathetic inflammation.

Small penetrating wounds of the sclera behind the ciliary body (danger zone) are rare, and usually require nothing more than to have the conjunctiva over them adjusted with fine silk sutures. Large scleral ruptures result usually from blows and are contre-coup in character. These wounds are usually larger than they appear to be, as the overlying conjunctiva seldom if ever sustains as large a wound as that in the sclera, and the scleral wound is concealed by the overlying conjunctival tissue. Usually eyes with large scleral ruptures are lost. If an attempt to save the eye is to be made, the conjunctiva should be carefully sutured, but it is better not to introduce sutures into the sclerotic coat.

If in any case there has been a possibility of the entrance of a foreign body into the globe, the X-ray should be used to determine whether or not a foreign body is present, and if it is to map out the size, shape and location of the body.

Injuries to the Eye by Foreign Bodies

In considering the subject of the treatment of injuries to the eye by foreign bodies, we are concerned chiefly with injuries to the cornea. Small foreign bodies do not usually penetrate to the interior of the globe, and except in the case of injury by gunpowder, those which strike the conjunctiva of the eyeball with too little force to penetrate to the interior, as a rule, fail to become embedded in this structure although they frequently adhere to the conjunctiva of the upper lid. Furthermore, injuries to the conjunctival and subconjunctival tissues are secondary in importance since they do not lead to impairment of vision as injuries to the cornea are prone to do.

Removal of Foreign Bodies from the Conjunctiva.—To remove foreign bodies from the conjunctiva of the upper eyelid all that is necessary as a rule is to evert the lid and wipe off the offending particle. *To turn the upper lid* the surgeon grasps the eyelashes between the thumb and forefinger of the left hand, and the patient is directed to look down. As the eye turns down the surgeon pulls the eyelid away from the eyeball slightly, and at the same time touches the lid at the upper margin of the tarsus or a little above it with a finger or any small article that may be convenient, such as a pencil, or toothpick swab. Then the foreign particle is wiped off with a clean cotton swab or damp cotton sponge. If the cornea has been scratched by rubbing of the foreign body through moving the lids, the eye will feel uncomfortable until the little wound is healed. To guard against infection, it is well to make a practice of instilling argyrol 25 per cent. after removing a foreign particle from the conjunctiva.

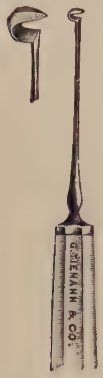


Fig. 50.—Author's Instrument for Removing Foreign Bodies from the Cornea.

If specks of powder have become embedded in the conjunctiva of the eyeball, it is usually impossible to pick them out. In order to remove them the surgeon must pick up each particle with the conjunctiva by means of a fine forceps and snip out the foreign particles with the least possible surrounding conjunctiva.

Removal of Foreign Bodies Embedded in the Cornea.—The surgeon should have absolutely good light and a lens with a focus of about 2½ in. to condense the light rays upon the foreign particle. In some cases it is necessary to depend upon concentrated artificial light and a magnifying glass to aid the vision of the operator. The cornea is anesthetized by the instillation into the eye of 4 per cent. cocain, 1 per cent. holocain or 3 per cent. alypin. Complete anesthesia is usually accomplished by 3 instillations at intervals of 2 or 3 minutes. Holocain and alypin have a slight advantage over cocain in that they do not dilate the pupil; and in the cases in question it is usually not desirable to dilate the pupil, as dilatation renders the eye more susceptible to discomfort from light. However, cocain is always efficient and for some patients the other anesthetics do not seem to give complete loss of sensibility, so that cocain is usually employed.

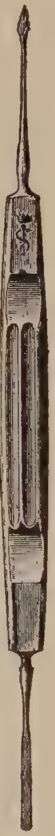


Fig. 51. — Foreign Body Needle and Spud Combined.

A number of instruments have been designed for the extraction of foreign particles from the cornea, but none of them is entirely satisfactory for all foreign bodies. Many of them can be easily removed with the ordinary "spud." The instrument shown in Figure 50 was designed by me especially for the general practitioner, and is safe in the hands of the surgeon not especially trained in eye surgery. The edge of the instrument is ground sharp and should cut with gentle pressure.

The patient is seated in a chair of such a height that his eyes will be in a position most easily accessible to the surgeon, who stands behind the patient and steadies his head. The light is thrown on the cornea with a condensing lens and the patient is instructed to keep both eyes open wide and to look with the uninjured eye at a definite object in such a direction that the foreign body can be distinctly seen. The surgeon, with his fingers, assists the patient in holding his eyes open. The surgeon works the edge of the instrument carefully under the foreign body and, if possible, with a single motion lifts the foreign body from its bed in the cornea. It is not always possible to do this, especially in the case of emery particles, which break up when manipulated; so a point has been provided on the instrument for such foreign bodies as cannot be removed by the cutting edge. In using this point, the shank of the instrument is made to act as a guard against penetrating the anterior chamber of the eyeball.

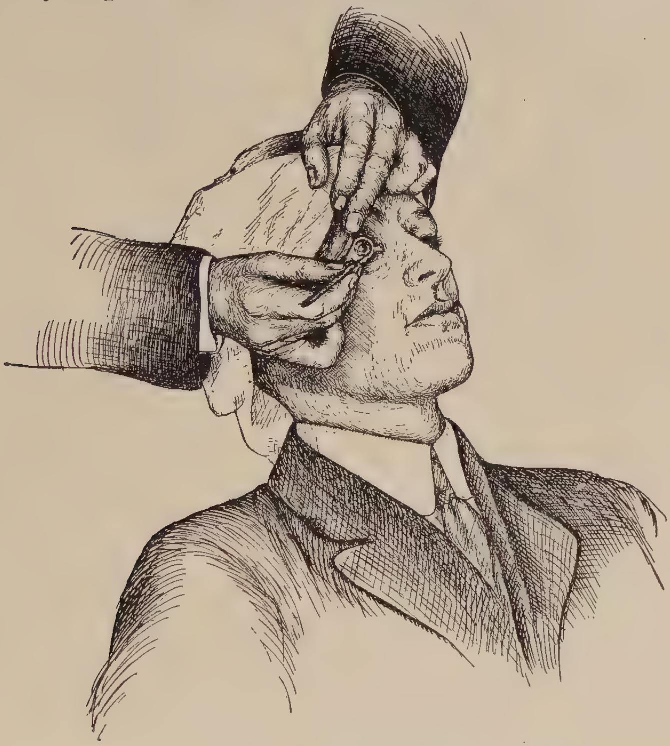


Fig. 52.—Removing Foreign Body from Cornea.

As a rule, if the foreign bodies are removed entirely, the little wounds heal up kindly. However, it is a wise precaution to prescribe argyrol 25 per cent. or some other mild antiseptic, to be used by the patient 3 or 4 times daily for a period of a few days, as occasionally infection in these wounds occurs and leads to ulceration of the cornea. If only the superficial epithelial layer of the cornea has been injured, the patient can be promised no impairment in

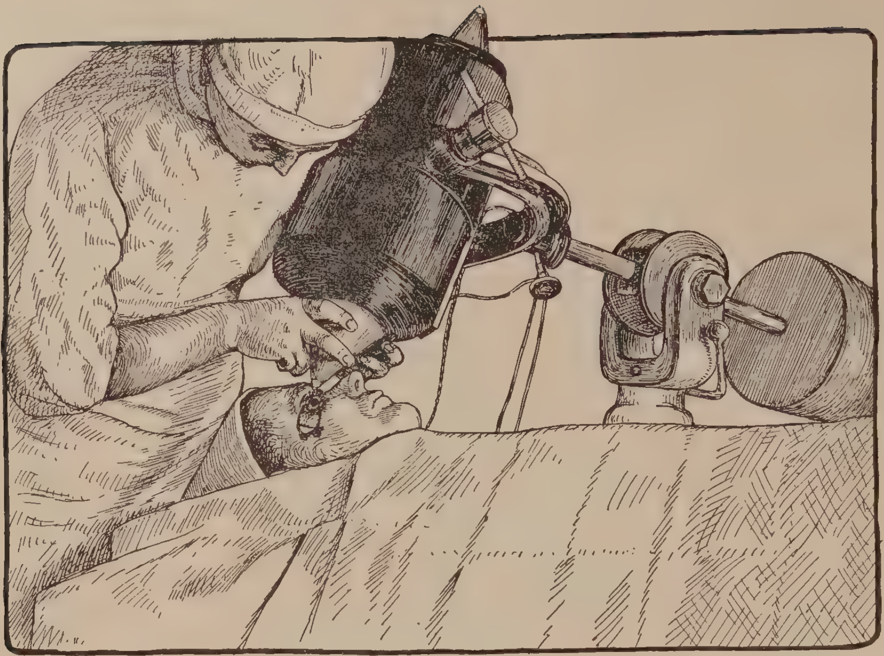


Fig. 53.—Magnet Extraction of Foreign Body in Globe. Giant magnet in position.

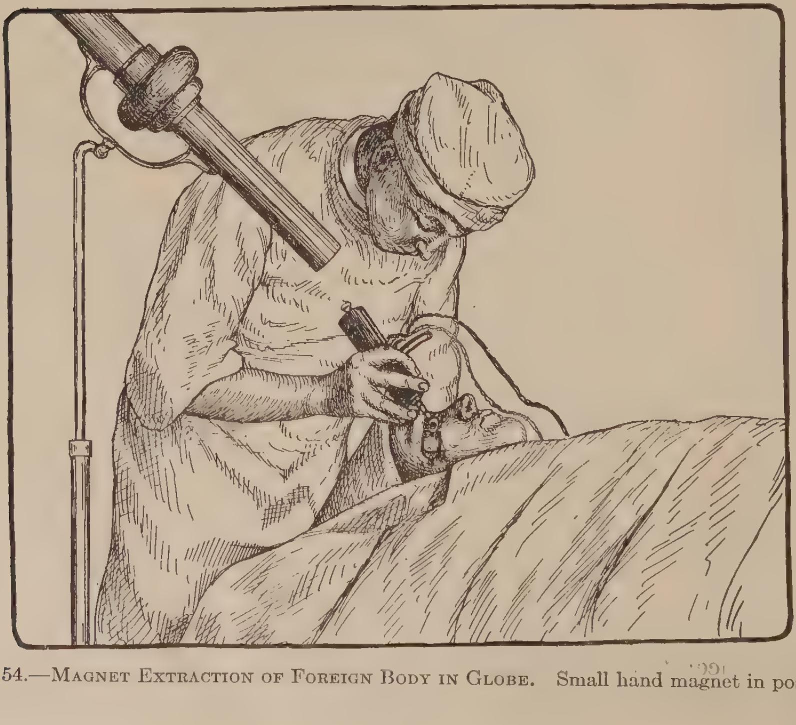


Fig. 54.—Magnet Extraction of Foreign Body in Globe. Small hand magnet in position.

his vision, but when the deeper layers are injured, scar formation always results and cicatricial tissue in the pupillary area means direct interference with the function of vision. And even if these scars are peripheral to the pupillary area of the cornea, irregular astigmatism of a greater or lesser degree results. This astigmatism cannot be corrected by any lens. Hence the seriousness of foreign body wounds of the cornea from the point of view of vision. Injuries to the cornea are oftentimes regarded too lightly by both surgeon and patient. Men who are working in shops and are prone to get foreign particles in their eyes should be cautioned to wear goggles while at work.

A number of medicaments have been recommended for the removal of scars from the cornea, but after a scar has once been formed, nothing can be applied which will remove it.

Removal of Foreign Bodies Which Have Penetrated to the Interior of the Eyeball.—In my opinion, the patients who are victims of such injuries should be sent at once to an eye surgeon who has been specially trained in extracting bodies from the globe.

Figure 56 is a reduction of a skiagraphic chart which shows a method of recording the localization of a foreign body in the interior of the eye. A radiographer skilled in the work can estimate to the fraction of a millimeter the position of minute or large foreign bodies which have penetrated the eyeball. (For detailed description of the Dixon method of localization see Weeks' "Diseases of the Eye.") There is considerable difference of opinion as to the best method of removing these bodies, but after a study of the technic of foreign body extraction, together with the results obtained, I am convinced that a non-magnetic foreign body hanging in

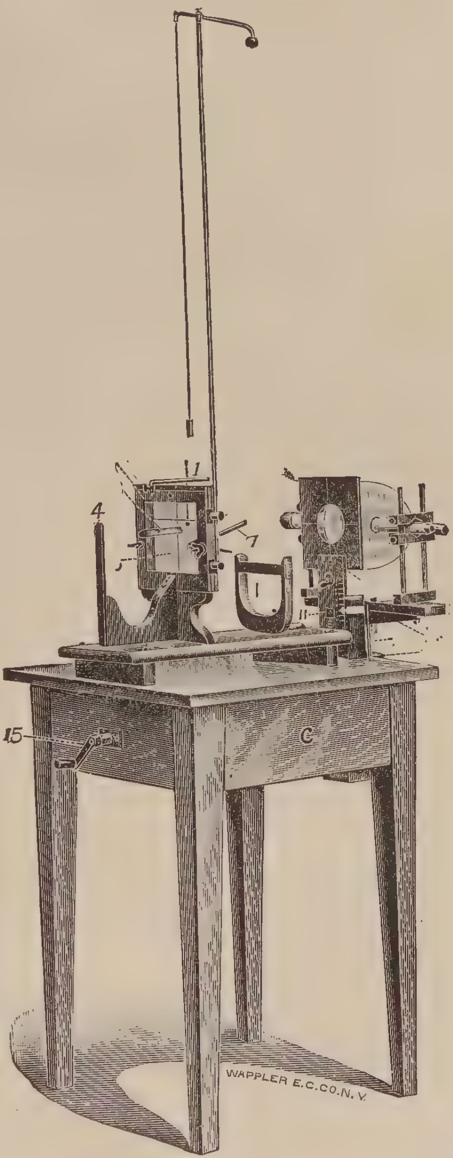


Fig. 55.—Dr. Dixon's Improved Apparatus for Localizing Foreign Bodies in the Eye and Orbit.

the vitreous should not receive operative interference unless the eyeball has to be removed. But if it is in contact with the wall of the globe, it may be removed through an opening as near as possible to the site of the foreign body. *Magnetic foreign bodies* should be drawn into the anterior chamber of the eyeball through the ligament of the lens by application of the giant magnet, or through the lens itself if it has been injured. They should then be drawn out of the anterior chamber through an incision in the cornea by application of a small hand magnet. During manipulation the eye is held open by a speculum made of silver or some other non-magnetic metal.

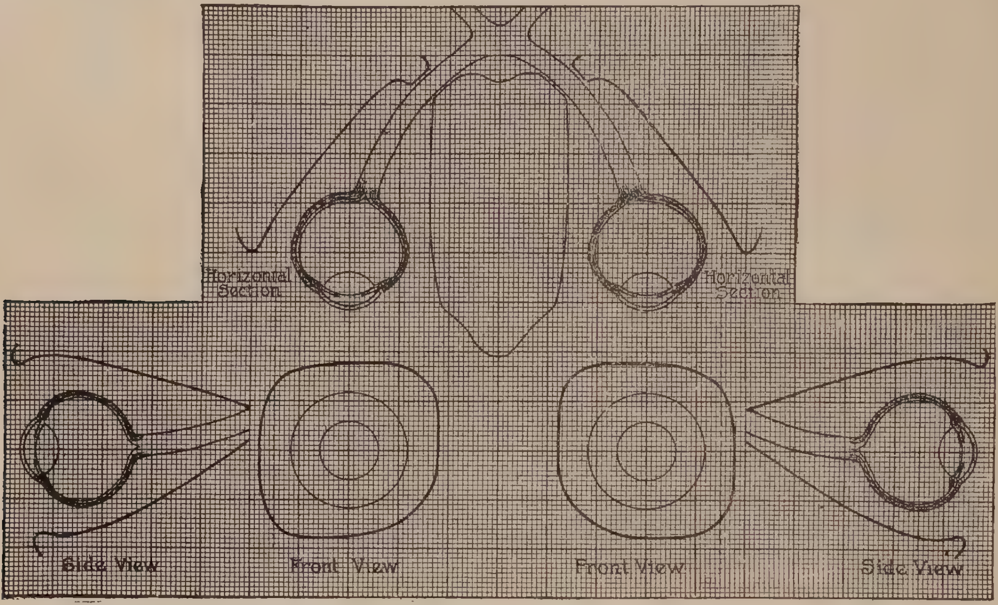


Fig. 56.—Dixon's Modification of Sweet's Chart.

Although the prognosis for eyes penetrated by foreign bodies is always grave, a large proportion of such eyes should be saved with good vision providing that the lens is not injured, and even in cases in which there has been injury to the lens good vision should follow extraction of the cataractous lens. Unfortunately some of the eyes injured by foreign bodies, strangely enough, degenerate months or years after apparently successful magnet extraction.

ENUCLEATION

INDICATIONS.—Indications for enucleation are *intra-ocular tumors* of malignant type; *absolute glaucoma* if the eye is painful and relief cannot be obtained by a less radical procedure; *panophthalmitis; injuries* in which the damage to the eye is of such an extent that the surgeon is sure that the eyeball cannot be saved, and *injuries in the ciliary region* which endanger the fellow eye through sympathetic inflammation; and any eye in which the vision is lost and the *disfigurement* is considerable.

INSTRUMENTS.—Speculum, mouse-tooth forceps, small curved scissors, strabismus hook, enucleation scissors, needle-holder and sutures.

ANESTHESIA.—General anesthesia should be employed. If it is not prudent to give chloroform or ether on account of a constitutional disease, the operation may be performed under nitrous oxid gas.

OPERATION.—After irrigating with boric acid solution, instill adrenalin 1:1,000 to control the hemorrhage. Introduce the eye speculum. If the anterior portion of the eyeball is badly lacerated the wound should be sewed up with silk sutures. If the sutures are left long after tying, they serve as a convenient means of holding the eye in whatever position the surgeon may wish during the enucleation. Even in cases in which there is no wound of the globe, as a matter of convenience a suture may be introduced into the cornea for directing the position of the eye.

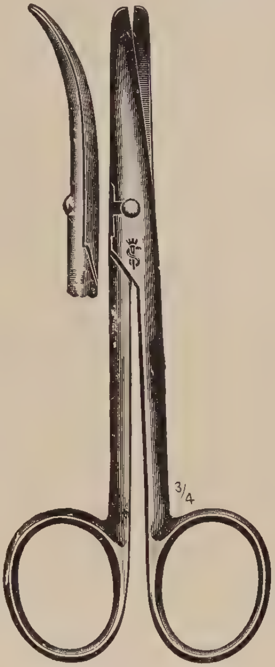


FIG. 57.—ENUCLEATION SCISSORS.

With the mouse-tooth forceps pick up the conjunctiva near the cornea and dissect this membrane free from the cornea all the way around with a pair of small curved scissors, and dissect the conjunctival and subconjunctival tissues from the globe far enough back to expose the insertions of the rectus tendons. Pick up the tendons on the strabismus hook one by one and cut them free from the eyeball at their insertions. Then force the globe forward as far as possible, either by making traction on a suture which has been left long or by prolapsing the globe through the speculum. Introduce the enucleation scissors behind the globe and feel for the optic nerve with the blades closed; and when the exact position is determined, straddle the nerve with the blades of the scissors and cut it. This allows the eyeball to come forward freely and the tissues which remain attached to the

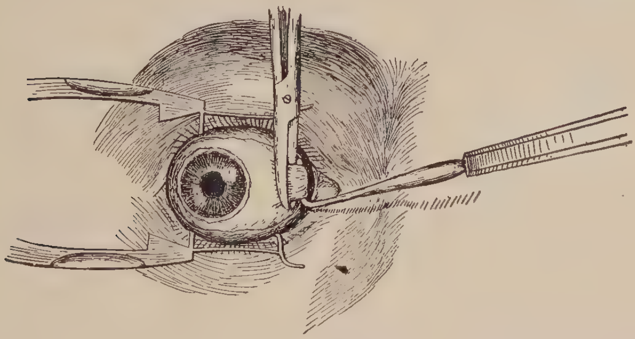


FIG. 58.—ENUCLEATION OF RIGHT EYEBALL. Conjunctiva has been dissected up, and muscle is about to be cut at its insertion.

globe may be dissected off easily. Tampon and make firm pressure with cotton sponges and maintain this pressure until the hemorrhage has ceased. It is not absolutely necessary to suture the conjunctival wound, but suturing will hasten healing and prevent the formation of granulation tissue in the wound. A fine gut suture is sufficient, and is usually introduced as a purse string.

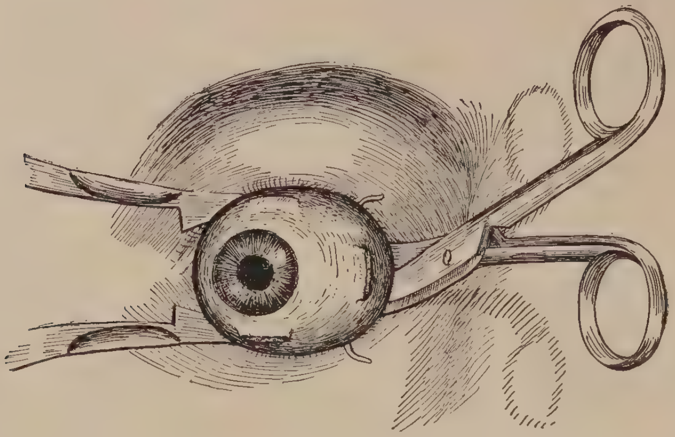


Fig. 59.—Enucleation of Right Eyeball. Scissors in position to cut optic nerve.

The dressing should be changed daily until the wound is healed, and at the end of 2 weeks or more an artificial eye should be introduced.

MODIFIED ENUCLEATION OPERATIONS.—There are many modifications of this operation and substitutes for it. Among these are *evisceration,* in which the contents of the eyeball are removed and the sclera is left with its muscular attachments, and procedures in which a glass or gold sphere is introduced into the sclera after evisceration or in Tenon's capsule after enucleation. There is considerable difference of opinion among ophthalmologists as to the relative value of these operations. Recently *fatty tissue* has been introduced into the cavity after enucleation with good results. The fat may be taken either from the abdominal wall or from the thigh. This may be done without danger of infection or other unfortunate results. In all cases of implantation of fat in Tenon's capsule, probably there is some absorption of the fatty tissue, but judging from the results in cases on which this operation was done several years ago, sufficient fat remains to preserve a good stump.

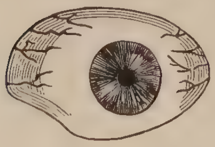


Fig. 60.—Artificial Eye.

ARTIFICIAL EYES.—After enucleation or any modification, an artificial eye must be carefully fitted to the socket. The cosmetic appearance following enucleation depends as much upon the prosthesis as upon the operation itself. Artificial eyes may be a source of discomfort to patients and may cause injury to the conjunctiva, resulting in granulation and cicatricial tissue.

When a patient complains of discomfort from a glass eye, the entire conjunctiva and lacrimal sac should be subjected to close scrutiny. If the lacrimal sac is diseased, it should be properly treated or removed. If the conjunctiva is inflamed, the artificial eye should be left out until proper treatment has restored the mucous membrane to its normal condition. Any granulation tissue present should be removed with scissors and the wounds cauterized with a lunar caustic pencil. From contraction of the cicatricial tissue sometimes it becomes impossible for a patient to hold an artificial eye. This is most liable to be the case if the enucleation has been improperly performed, or if the conjunctiva has undergone cicatricial contraction through a serious injury or a burn from lime or acid. Complete obliteration of the conjunctival cul-de-sac may result in these cases. For such a condition it sometimes becomes necessary to form new cul-de-sacs by the transplantation of skin grafts. The operation for the restoration of sockets by this means is difficult and tedious and not always satisfactory in its results, especially when a new upper cul-de-sac has to be made and the tendon of the levator palpebræ superioris is injured. The technic of this operation is described on page 71.

OPERATIONS ON THE EYELIDS

SURGICAL ANATOMY OF THE EYELIDS

The eyelids are movable folds for the protection of the eyeball. The normal lids are capable of absolute approximation. When separated the eyeball is partly exposed and the opening between the lids is known as the *palpebral fissure.* The outer angle of this opening is known as the *external canthus* and the inner angle as the *internal canthus.* At the inner canthus there is a little triangular space which exposes, when the eyes are open, a small reddish elevation known as the *caruncle.* About 5 mm. from the inner canthus on each lid is a minute opening known as the *lacrimal punctum* for the passing of tears into the canaliculus, which communicates with the lacrimal sac and allows drainage of the tears into the nose through the nasal duct.

At the lid margins are eyelashes or *cilia.* Purulent infection around the roots of the eyelashes results in the formation of the familiar pus collection known as hordeolum or sty. The skin and subcutaneous tissue of the lids are lax and lie in little folds. The usual laxity of these tissues accounts for the marked swelling which occurs from contusions, infections, and vascular disease. The *orbicularis palpebrarum* muscle lies beneath the skin and subcutaneous tissue, with its fibers running in a curved direction around the eyelids. Contraction of this muscle causes approximation of the lid margins or closure of the eyes. Lying beneath the orbicularis muscle in each eyelid is a *tarsus* or tarsal plate extending from one end of the palpebral fissure to the other. These plates are composed of tough connective tissue of cartilaginous consistency, and it is through them that the conformity of the lids and lid margins is preserved. These plates are pointed at the ends; in the upper lids they have a width in the center of about 8 mm. and in the lower lids a width of 5 or 6 mm. The ends of the tarsal plates are connected with the orbital margin by bands of ligamentous tissue known as the internal and external tarsal, canthal or palpebral ligaments.

The posterior surfaces of the tarsal plates have numerous grooves for the *Meibomian glands,* which secrete a sebaceous material to prevent the lid margins from sticking together. The ducts of these glands open behind the eyelashes in the lid margins. It is through blocking of one of these ducts and the cystic collection of Meibomian gland secretion together with chronic inflammation which produces the familiar condition termed chalazion.

Lining the eyelids is a layer of well vascularized mucous membrane known as the *conjunctiva.* This is folded over on the anterior surface of the eyeball.

The tissues of the eyelids are well supplied with blood by the *palpebral arteries,* which run close to the lid margin between the orbicularis muscle and the tarsus.

EPILATION OF EYELASHES

Frequently in cases of old trachoma, with cicatricial turning in of the eyelids, the cilia rub against the cornea and become a source of irritation and annoyance to the patient. Less often this condition results from burns of the conjunctiva and from injury to the eyelids, and sometimes without apparent cause. Pulling out the eyelashes is of only temporary benefit, but will give relief until they can be directed away from the eyeball by an operative measure, or permanently removed.

For epilation, only a good pair of cilia forceps is necessary (Fig. 61). The patient should be seated in a good light. The operator with one hand slightly everts the lid margin by making gentle pressure on the skin of the lid a few millimeters from the margin, and with the other hand grasps the eyelashes one by one with the cilia forceps and pulls them out with a slightly lateral motion, so that they will not slip out of the forceps. After removing the offending cilia that are apparent, it is well to examine for very fine or broken lashes with a loupe, and to remove them carefully. Of course new eyelashes will appear to replace those epilated.

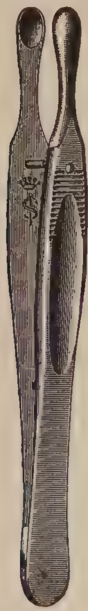


Fig. 61.—Cilia Forceps.

ELECTROLYSIS OF CILIA FOLLICLES

If only a few hairs are rubbing against the eyeball the best way to get rid of them is by electrolysis. The procedure is painful and should be done under general narcosis or cocain infiltration anesthesia. If cocain is used, 4 per cent. solution should be injected through the skin in sufficient quantity to thoroughly anesthetize the portion of the lid which holds the offending hairs. The lid is held in eversion by a clamp such as that of Knapp or Desmarres, or by a Jaeger lid plate. A galvanic current with a rheostat is employed for the electrolysis. At the negative pole is a fine sharp needle, and at the positive pole is a small sponge. The sponge should be dipped in water or salt solution and held against the patient's temple or forehead. The fine needle at the negative pole should be introduced along an offending eyelash into the follicle, a distance of about 3 mm. and, with the sponge in position, the current should be turned on gradually until bubbles appear around the needle. After about a half minute of bubbling, the current is turned off or broken by removing the sponge, and the eyelash is lifted out with the cilia forceps. If the current has been applied successfully the eyelash will offer no resistance and the destruction is permanent. No dressing is necessary.

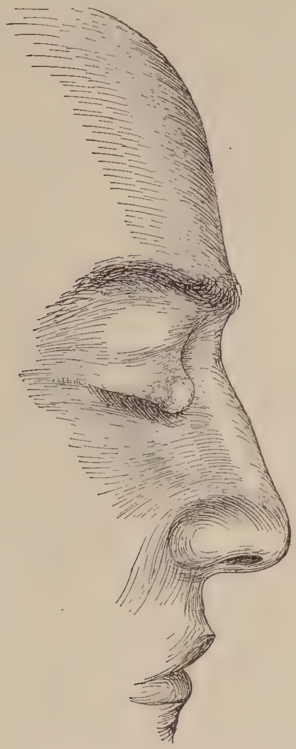


Fig. 62.—Large Chalazion of Right Upper Eyelid.

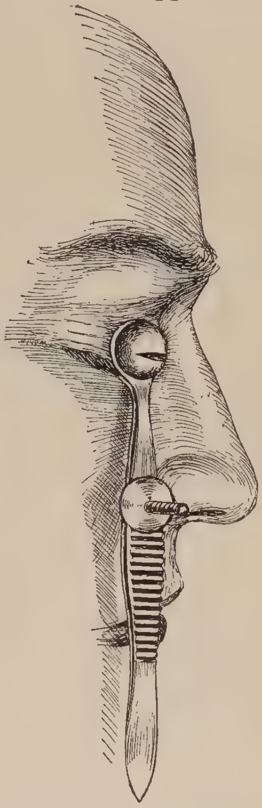


Fig. 63.—Excision of Chalazion. Skin incision.

HORDEOLUM (STY)

A little pus collection about the follicles of an eyelash, commonly known as a sty, does not necessarily call for operative interference, but it may be a painful and annoying condition and incision and evacuation of the pus will cut short its course.

Injection of cocain into the tissues about the hordeolum renders the incision almost painless. In order to be sure not to injure the eyeball during this procedure, grasp the lid between the thumb and forefinger of the left hand and open the sty quickly but freely with a sharp knife and thoroughly squeeze out its contents. Ordinarily, curetting is not necessary. Hot bathing will hasten the healing process after incision, and ointment applied to the margin of the eyelids will prevent their sticking together during sleep.

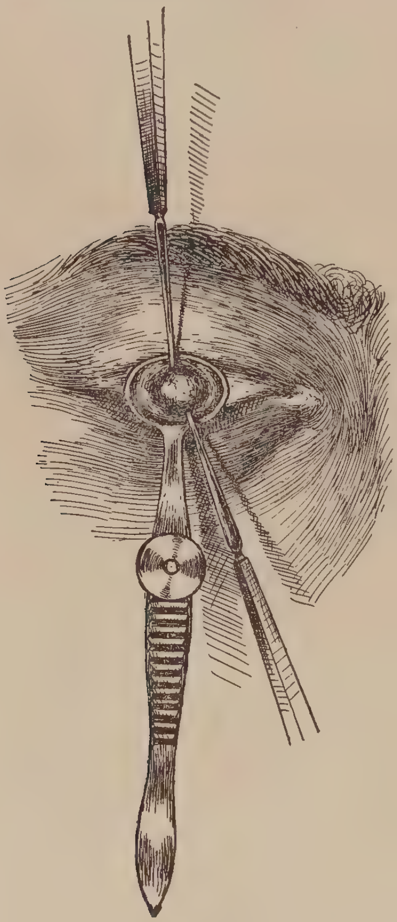


Fig. 64.—Excision of Chalazion. Dissection has been completed except for cutting off at base.

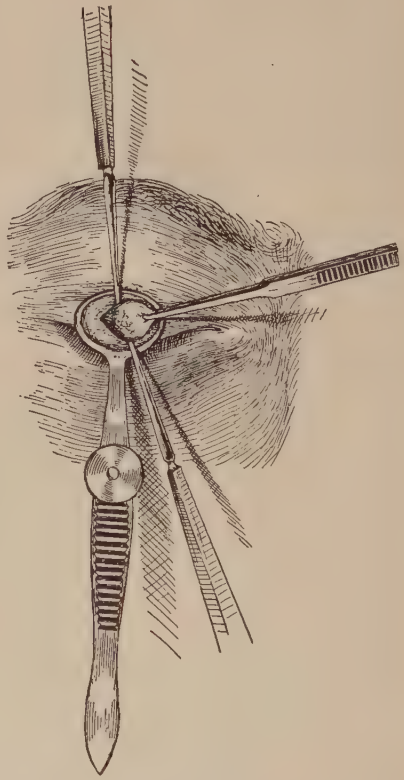


Fig. 65.—Excision of Chalazion. Skin retracted to facilitate dissection.

CHALAZION

Chalazion is a chronic affection of a Meibomian gland (Fig. 62), resulting in a cyst of the eyelid with thickened walls. It develops slowly, and usually without irritation. As a rule no harm arises aside from a slight disfigurement, but occasionally a chalazion becomes infected and an inflammatory process results.

These little cysts may be curetted either through the conjunctiva or lid margin, but thickened tissue is liable to be left behind, and a recurrence is not infrequent. It is better to carefully dissect out the chalazion with its wall through an incision in the skin if the growth is in the upper lid, or through the conjunctiva if it is in the lower lid.

First anesthetize the conjunctiva by instilling 4 per cent. solution of cocain. Then inject cocain 4 per cent. and adrenalin 1:1,000 equal parts into the tissue of the lid around the cyst. Apply the chalazion clamp to the anesthetized lid so as to completely shut off the circulation (Fig. 63). Make the incision down to the cyst wall and carefully dissect out the chalazion. If the cyst is ruptured in the manipulation, carefully curet any particles that remain, as recurrence depends upon leaving part of the wall.

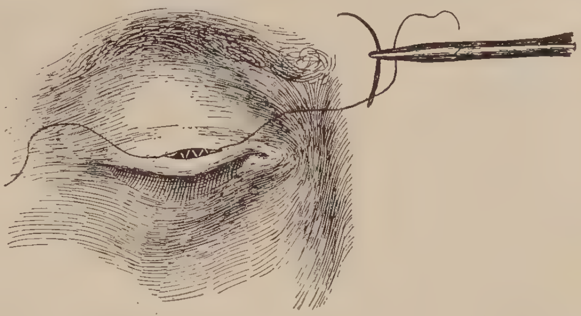


Fig. 66.—Excision of Chalazion. Subcuticular silk suture.

A conjunctival incision will need no suture, but if the incision is made in the skin a subcutaneous suture (Fig. 66) may be introduced and allowed to remain for a day or two. The wound should be kept under a dressing until the suture is removed.

SCARIFICATION AND EXPRESSION FOR TRACHOMA

In the follicular type of trachoma the contents of the follicles can be removed by opening them and expressing them with forceps.

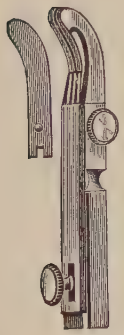


Fig. 67.—Week's Multiple-bladed Scarifier.

INSTRUMENTS.—Forceps for everting lids, scalpel or multiple-bladed scarifier, trachoma forceps such as Knapp's roller forceps.

OPERATION.—General anesthesia should be used, as this operation is most often performed on children and is quite painful. The eyelid is doubly everted with the lid forceps or Prince ring forceps and the follicles are opened by scarifying the conjunctival surface very lightly. If deep cuts are made permanent scars with adhesions are liable to result. Following scarification the contents of the follicles are squeezed out with trachoma forceps. A good way is to work with two pairs of Knapp's roller forceps and "milk the tissues" until the conjunctiva is smooth, taking great care not to lacerate the conjunctival tissue. The Prince forceps is a suitable instrument for working at the angles and expressing the follicles of the semilunar folds. After the expression is completed the conjunctiva of the lids should be rubbed thoroughly with cotton swabs wound hard and saturated with a solution of bichlorid 1:5,000, and then thoroughly anointed with vaselin or albolene.

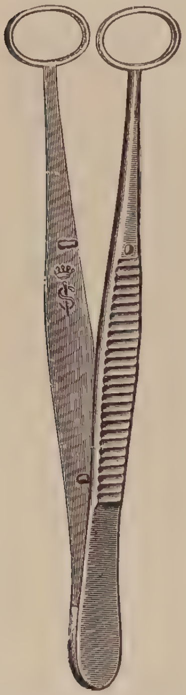


Fig. 68. — Prince Trachoma Forceps.

The reaction following this operation is controlled by almost constant application of ice pads for 24 hours. During the few days following scarification and expression, a thin fibrinous membrane forms on the conjunctival surface of the eyelids, which may be wiped off gently. There is a strong tendency toward conjunctival adhesions (symblepharon). These should be prevented by the use of the probe and by keeping the tissues anointed with sterile vaselin or albolene or some mild antiseptic ointment.

In a few days after operation local treatment, consisting of applications of copper sulphate or bichlorid solution 1:5,000, should be continued until the trachomatous process is eliminated.

In the more severe type of trachoma in adults, accompanied by corneal ulceration and pannus, the most satisfactory procedure is the resection of the tarsus with the conjunctiva. The technic of this operation is described on page 68.

ECTROPION

Ectropion is a turning out of the eyelid, and occurs more commonly in the lower than in the upper lid. *Spastic* ectropion is a flopping of the tarsal portion of the eyelid and is caused by spasm of the orbicularis palpebrarum muscle. *Senile* ectropion is a drooping as well as eversion of the lower lid, associated with lack of tone in the tissues of the lid. *Cicatricial* ectropion is caused by contraction of scar tissue in the superficial layers of the eyelid.

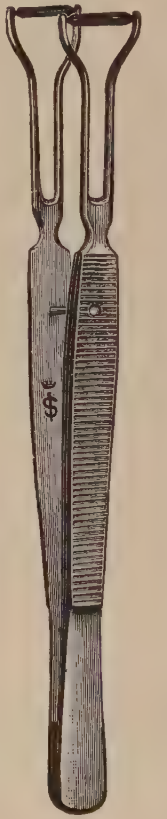


Fig. 69. — Knapp's Trachoma Forceps.

Spastic Ectropion.—This condition is occasionally seen in children who have an acute inflammatory disease of the eye. It is a temporary condition and usually calls for only temporary means of relief. This is found in the *Snellen* sutures. Usually 2 double-armed silk sutures are introduced through the conjunctiva of the everted lid and brought out on the skin of the face below the orbital margin. The needles should be made to enter the conjunctiva at the angle of eversion which corresponds approximately with the convex margin of the tarsus. The 2 needles of one suture enter about 2 mm. from each other and approximately midway between the center of the eyelid and each end. They are carried through the subcutaneous tissue somewhat beyond the margin of the orbit and are brought out through the skin, and there tied tight enough to hold the eyelid against the eyeball. These sutures may be left in until the inflammatory process of the eye has subsided unless an infection makes their removal necessary. The procedure is very easy of performance and gives satisfactory results in the spastic variety of ectropion.

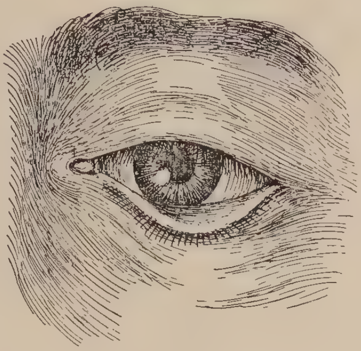


Fig. 70.—Senile Ectropion.

Senile Ectropion.—As the name implies, this condition is found most often in elderly people whose tissues have become lax. The lower lid drops away from the eyeball, the conjunctiva becomes thickened and the lid margin rounded, producing an unsightly appearance of the eyelid, associated with overflowing of tears. Cautery puncture into the substance of the lid through the conjunctiva as described by Ziegler will suffice for a slight ectropion of this character. When the condition is marked, the plastic operation of Kuhnt and Meller is efficacious.

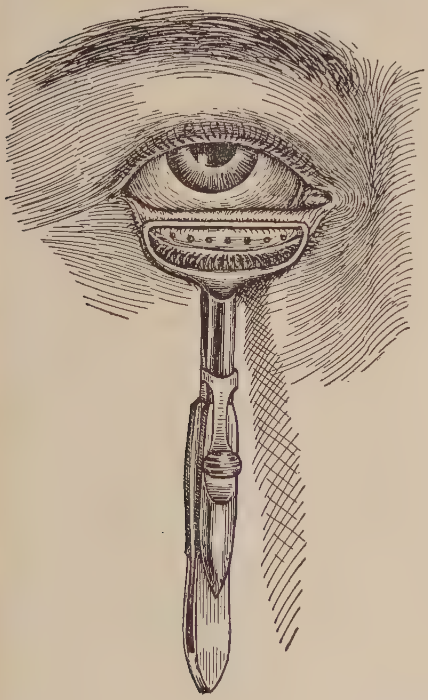


Fig. 71.—Cautery Puncture for Ectropion.

CAUTERY PUNCTURE.—After anesthetizing the eyelid with cocain and adrenalin injection, apply the lid clamp of Ziegler or some other good forceps to hold the eyelid in position and make a row of punctures 4 mm. from the lid margin and 4 mm. apart (Fig. 71). This procedure may be repeated as many times as necessary to bring the lid in position. The reaction following this operation is slight and a dressing is not necessary. Vaselin may be applied to the cauterized area until the little wounds are healed.

KUHNT-MELLER OPERATION FOR SENILE ECTROPION.—Anesthesia.—

This operation may be done under either local or general anesthesia. A solution made up of cocain 2 per cent. and adrenalin 1:1,000 equal parts is satisfactory for injection. If general anesthesia is used, adrenalin solution should be injected into the tissues, as considerable bleeding would occur otherwise.

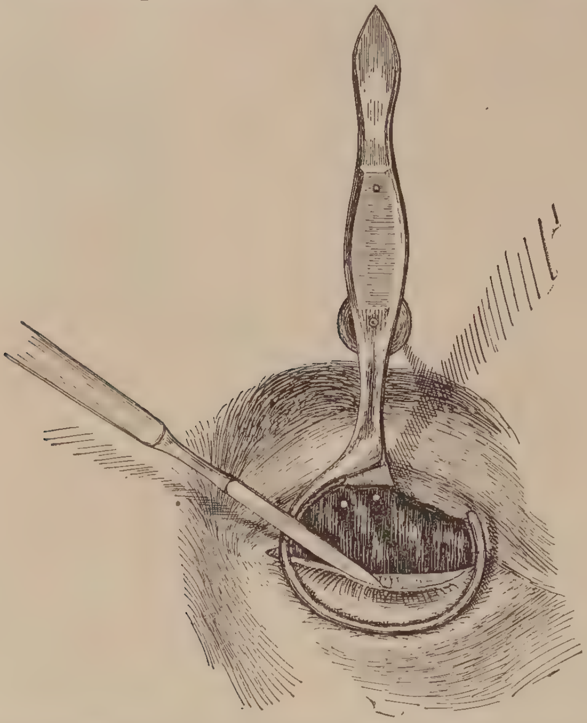


FIG. 72.—KUHNT-MELLER OPERATION FOR SENILE ECTROPION. Splitting the lower lid margin, left eye.

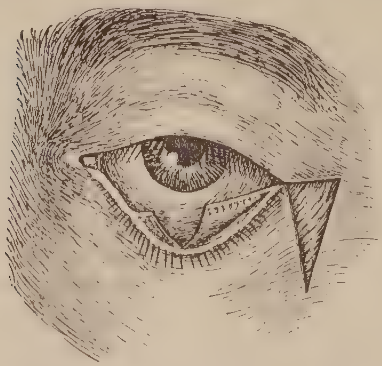


FIG. 73.—KUHNT - MELLER OPERATION FOR SENILE ECTROPION. Triangles have been removed from tarsus and skin.

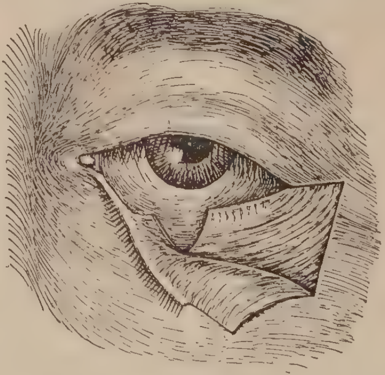


FIG. 74.—KUHNT-MELLER OPERATION FOR SENILE ECTROPION. Dissection complete.

INSTRUMENTS.—Lid clamp (such as Desmarres' or Knapp's), scalpel, anatomical forceps, mouse-tooth forceps, straight and curved scissors, needle-holder, 3 double-armed fine silk sutures and several single-armed silk sutures.

OPERATION.—The first step is to split the lower lid. To accomplish this apply the clamp so as to hold the lid in position and to control the hemorrhage (Fig. 72). Make an incision in the outer two-thirds of the margin of the eyelid with a fine scalpel or a Graefe knife. This incision should divide the margin of the eyelid in such a way as to leave the cilia and cilia follicles in the anterior flap and the tarsus in the posterior flap. After starting the splitting of the lid with the knife, the dissection is carried down with the scissors as far as the clamp will allow. This will be found easy if an assistant holds the anterior flap forward while the surgeon holds the posterior flap backward in such a way as to keep open the wound for dissection.

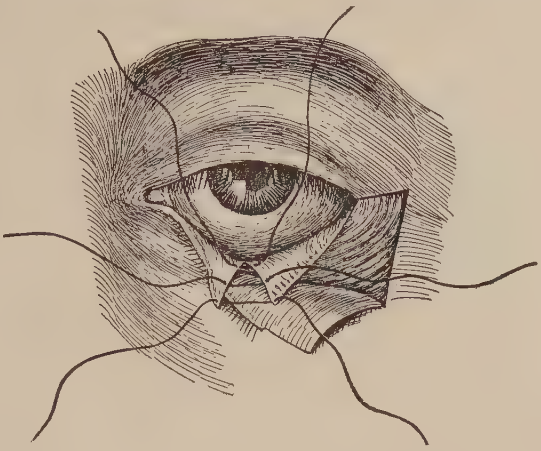


FIG. 75.—KUHNT-MELLER OPERATION FOR SENILE ECTROPION. Sutures in tarsus ready to tie.

Next remove the clamp and resect a triangular portion of the tarsus and conjunctiva from the posterior flap. The size of the portion excised should be governed by the amount of ectropion, enough being removed to bring the eyelid in apposition to the eyeball. The base of this triangle is at the lid margin and the apex at the lower margin of the tarsus.

The next step in the operation consists in removing a triangle of skin in the region of the outer canthus. The base of this triangle should be as long as that of the tarsal triangle just removed or a little longer and should be in line with the direction of the margin of the lower lid, extending from the external canthus outward and slightly upward. Make an incision from the external canthus downward and outward at right angles to the one just made. The ends of the 2 incisions are connected by a third and the triangle of skin removed (Fig. 73). Next undermine the skin flap of the lid thoroughly so that this flap will slide over and cover the denuded area. While an assistant holds the skin flap out of the way, the surgeon brings the 2 tarsal flaps to-

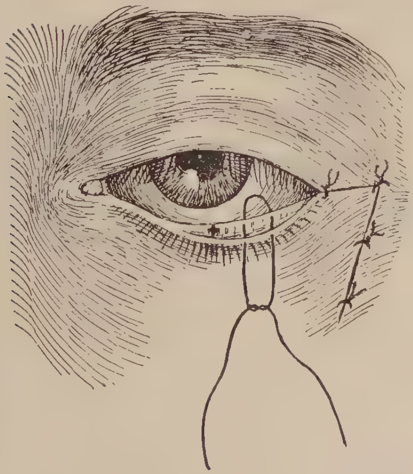


FIG. 76.—KUHNT-MELLER OPERATION FOR SENILE ECTROPION. Operation complete except for tying mattress suture in lid.

gether with 3 double-armed silk sutures, introduced about 1 mm. from the cut edges of the tarsus and in such a way as to bring the knots toward the conjunctiva. Pass the needles of the first suture at the lower margin of the tarsus. The needles carrying the second suture should pierce the tarsus and conjunctiva midway between the 2 margins, and the third near the border of the lid (Fig. 75). After tying the sutures, cut them off rather close, so that there will be as little irritation as possible to the eyeball.

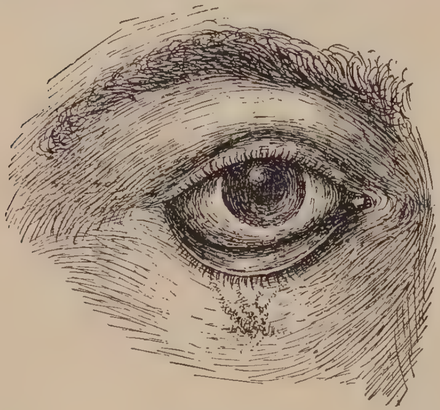


Fig. 77.—Cicatricial Ectropion of Right Lower Lid.

Before sewing the skin flap in position destroy the cilia, which would come external to the outer canthus, by cutting away a very narrow strip which will include the cilia follicles. Sew the skin flap in position by means of as many sutures as may be necessary, and if the flaps should not lie in good position a mattress suture may be introduced through the two layers near the lid margin.

This operation gives most satisfactory results in senile ectropion. The eye should be kept under a dressing for 4 or 5 days, when the sutures may be removed. It is well to change the dressing daily and to remove any secretion that may form.

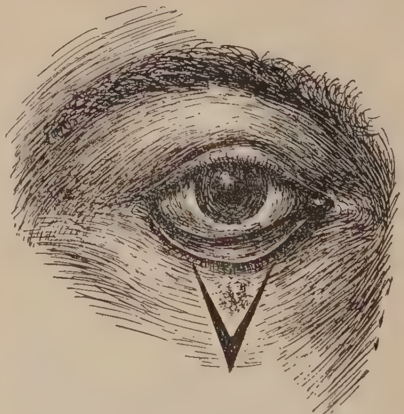


Fig. 78.—V-shaped Incision in Wharton-Jones Operation.

Cicatricial Ectropion.—Ectropion from scar tissue is more common in the lower lid than in the upper. It develops usually as a result of burns or traumatism. When it is the result of an accident, it may be associated with fracture of the orbital margin. There is no operation for this condition which gives a perfect cosmetic result, but plastic operations will in some cases make it possible for the patient to close the eyelids and at the same time improve the appearance somewhat.

WHARTON-JONES OPERATION.—This procedure sometimes gives beneficial results if the scar is in the lower lid and near the lid margin. The operation may be done under cocain and adrenalin injection anesthesia. Two converging incisions are made which include the cicatricial tissue and meet to form a V with the apex downward. The skin, including the scar tissue, is then dissected up nearly to the lid margin and the eyelid is placed in apposition to the eyeball. The skin on each side of the flap is undermined for a short distance and the lower parts of the margins of the 2 flaps are brought together with sutures and the upper parts are sewed to the flap of skin which includes the cicatricial tissue. Thus the V which is outlined by the primary incisions is converted into a Y. To keep the lid in a position of overcorrection, it may be sewed over the upper lid and kept in this overlapping position for a few days. The wound sutures should be left in for 5 or 6 days.

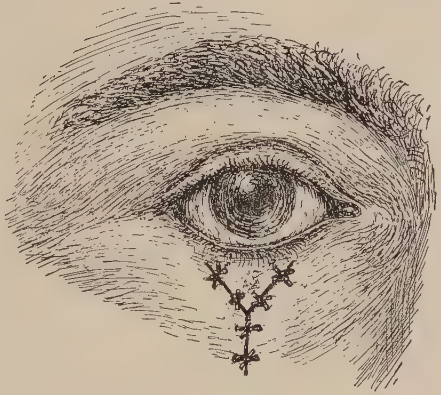


FIG. 79.—Y-SHAPED WOUND AT COMPLETION OF WHARTON-JONES OPERATION.

SKIN GRAFTING FOR CICATRICIAL ECTROPION.—Grafts without pedicles may be employed successfully in cicatricial ectropion of the upper lid. After healing, the graft is sometimes hardly apparent when the eyes are open. In the lower lid the cosmetic effect following grafting is not pleasing, as the grafted flap assumes a different color from that of the surrounding skin and is always more or less a blemish. However, it may be wise in certain cases to place grafts in the lower lid in order to protect the eyeball.

INSTRUMENTS.—Horn plate, small scalpel, mouse-tooth forceps, plain forceps, curved scissors, needle-holder and several silk sutures.

OPERATION.—General anesthesia is required. The area which is to receive the graft is prepared by dissecting away the cicatricial tissue and undermining the skin until the eyelid will fall into its natural position, and the lid margins are sutured together. The graft may be taken from the inner side of the thigh or arm. It should be ⅓ to ½ larger than the exposed area in the eyelid. There is a tendency to use too thick flaps in grafting operations; the flap should include the entire thickness of the skin, but no subcutaneous tissue. No special technic is required in handling the graft. It is laid on the denuded area of the lid and enough sutures are introduced to hold it in place (Fig. 80). Vaselin dressing and bandage are applied and kept on for about a week, when the sutures may be removed. It is well to keep the eyelids sewed together for several weeks.

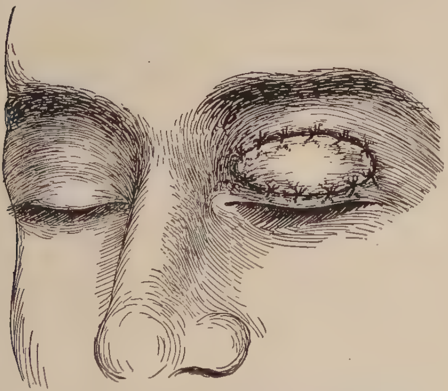


FIG. 80.—SKIN GRAFT WITHOUT PEDICLE FOR CICATRICIAL CONTRACTION OF UPPER LID.

Grafts with pedicles are sometimes satisfactorily employed in cicatricial ectropion. The accompanying illustration (Fig. 81) indicates a procedure in which the graft is taken from the temple and planted on the upper lid, leaving a good-sized pedicle. After placing the graft on the denuded area in the eyelid, the skin from the temple is undermined enough to allow the margins to be brought together over the exposed area of the temple. This operation offers nothing over a graft without a pedicle from the arm or thigh, and a scar remains on the temple.

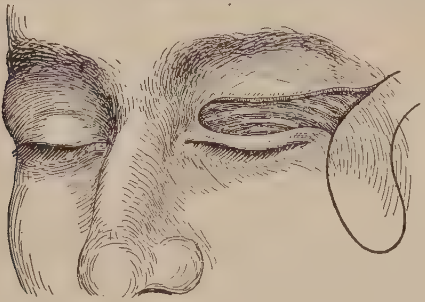


Fig. 81.—Skin Graft with Pedicle for Cicatricial Contraction of Upper Lid. Upper lid prepared for reception of flap outlined on the temple.

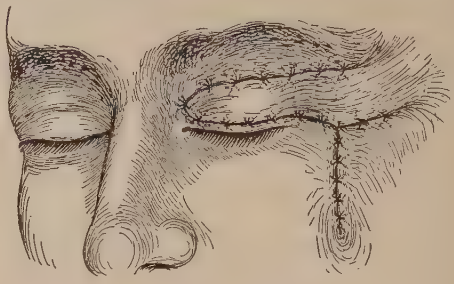


Fig. 82.—Skin Graft with Pedicle. Operation completed.

ENTROPION

Turning in of the eyelid may be spasmodic (spastic) or cicatricial. In entropion the eyelashes rub against the cornea and thus cause considerable distress to the patient.

Spastic Entropion.—This condition is more common in the aged than in the young. In old people it is referred to sometimes as senile entropion. This type of entropion results from spasm of the orbicularis muscle, usually dependent upon an irritable or painful condition of the eyeball. It is not uncommon following cataract extraction. Strips of adhesive plaster or collodionized cotton or gauze may be applied in such a way as to evert the lid. Most often, however, these means are unsatisfactory, as an overflow of tears loosens the adhesive plaster or other substance which has been applied.

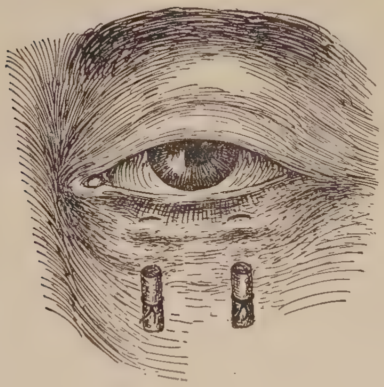


Fig. 83.—Sutures for Spastic Entropion.

GAILLARD SUTURES.—Gaillard sutures are found satisfactory in many cases of spastic entropion. No anesthesia is necessary for their introduction. The surgeon needs merely 2 double-armed silk sutures and a needle-holder. The 2 needles on the suture are made to enter the skin about 2 mm. apart and a few millimeters from the border of the lid and are carried under the skin to emerge near the orbital margin, where they are tied over a roll of gauze or a bead or directly over the skin (Fig. 83). The 2 double-armed sutures are placed at points about equidistant from each other and the ends of the eyelid. The sutures may be allowed to remain for 2 weeks or more if no infection takes place and if they are producing no discomfort.

ZIEGLER CAUTERY PUNCTURE.—The Ziegler cautery puncture is a procedure which gives sure results in cases of spastic entropion which do not respond to other forms of treatment. The eyelid is injected with cocain solution and a clamp applied to hold the lid in position or the lid may be held on a horn plate. A series of punctures is made parallel with the lid margin and 2 or 3 mm. from it with the electrocautery (Fig. 84). Each puncture should be carried well into the tarsus. After this operation it is well to apply bichlorid vaselin, dressing and bandage to remain for 24 hours.

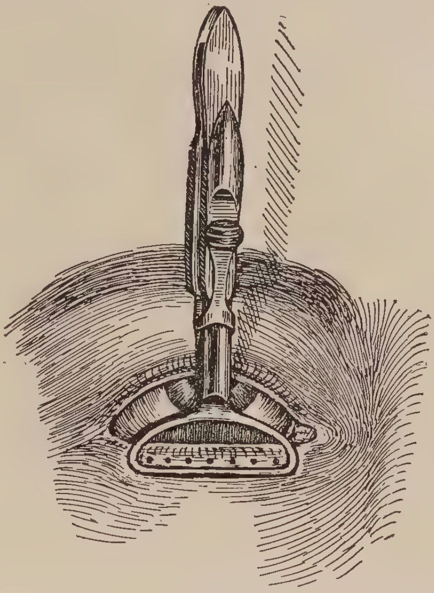


FIG. 84.—CAUTERY PUNCTURE FOR ENTROPION.

Cicatricial Entropion.—Cicatricial entropion is most often due to old trachoma; that is, the condition develops in the cicatricial stage of trachoma. The lid margin becomes rounded and the eyelashes rub against the eyeball and become distorted. This condition is often referred to as trichiasis. Many operations have been devised for correcting this condition. One of the most effective is the tarsal resection described on page 68. Aside from the tarsal resection, which is rather radical, perhaps none is more satisfactory than a modification of Snellen's operation.

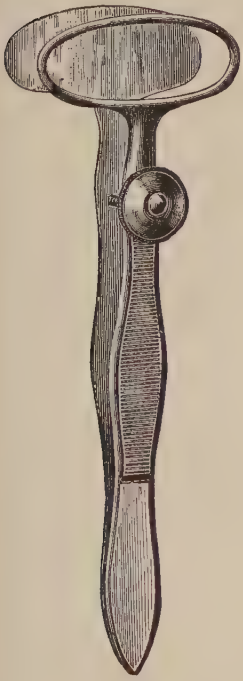


FIG. 85.—LID CLAMP.

SNELLEN'S OPERATION (MODIFIED) FOR TRICHIASIS.—INSTRUMENTS.—Jaeger or Knapp lid clamp, scalpel, mouse-tooth forceps, scissors, needle-holder and 3 or 4 silk sutures.

ANESTHESIA.—Either cocain and adrenalin injection of the tissues of the lid or general anesthesia may be used.

OPERATION.—First secure the clamp so as to hold the lid in position and to control hemorrhage. Make an incision about 2 or 3 mm. from the lid margin through the skin and orbicularis muscle. This incision should extend nearly the whole length of the lid. Remove a strip of orbicularis muscle and skin wide enough to expose the tarsus. The next step in the operation is to remove a wedge of tarsal tissue by making 2 incisions about 2 mm. apart throughout the length of the tarsus and slanting toward each other in such a way as to meet at the conjunctiva lining the lid but not to pierce it.

Introduce each of the 3 sutures as follows: Pass the needle through the skin and orbicularis muscle near the margin of the eyelid. Then enter the tarsus just above the groove which has been made, and lastly pass the needle through the orbicularis and skin at the upper margin of the tarsus. By tying these 3 sutures tightly the tarsus is everted and the entropion is overcorrected. There seems to be no danger of permanent overcorrection from this operation. The eye is kept under a dressing and bandage for a few days and the sutures should be allowed to remain for about a week.

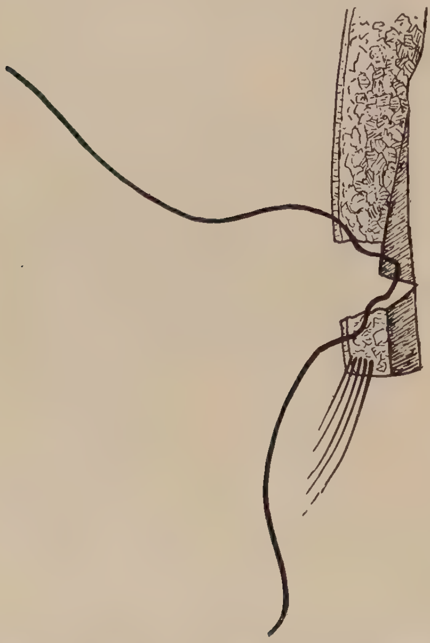


FIG. 86.—SNELLEN OPERATION (MODIFIED), SHOWING SUTURE READY TO BE TIED.

CANTHOPLASTY.—Canthoplasty is an operation designed to lengthen the palpebral fissure and to relax the eyelids by severing the external canthal ligament.

INSTRUMENTS.—Straight scissors, small curved scissors, mouse-tooth forceps, needle-holder, and 3 silk sutures.

OPERATION.—Cocain and adrenalin injection gives sufficient anesthesia. The eyelids are separated slightly and with straight scissors an incision is made through the entire thickness of the tissues at the outer canthus in a horizontal direction. The length of this incision must depend upon the amount of effect desired. It is wise to introduce the speculum after making this incision in order to expose the small field of operation and to control the hemorrhage. A piece of the external canthal ligament should be dissected out with forceps and scissors in order to make the effect of the operation permanent. The edges of the conjunctiva and skin are carefully sewed together with three sutures.

Vaselin should be applied to the wound daily until healing has taken place, and the eye kept under a dressing for a few days. If the sutures do not fall out within 5 or 6 days they should be removed.

TARSORRHAPHY.—This is an operation designed to shorten the palpebral fissure. It is performed most often in cases of facial paralysis with inability to close the eyelids, and rarely in Basedow's disease. The most satisfactory tarsorrhaphy operation is that of Fuchs. Cocain and adrenalin anesthesia is employed.

Instruments.—Horn plate, scalpel, tooth forceps, scissors, needle-holder, 1 double-armed silk suture and 2 or 3 single-armed fine silk sutures.

Fuchs describes the operation as follows:

> "First, the extent to which it is desired to join the lids together is marked out; then to the same extent the lower lid is split into its two laminæ by an intermarginal incision. From the inner extremity of the section a short incision is carried downward through the skin, thus converting the anterior lamina of the bisected portion of the lid into a flap. The upper and inner borders of this flap are free, while the lower and outer borders are connected with the skin of the lid. The follicles of the cilia, which lie exposed along the posterior border of the upper end of the flap, are removed by a scissors applied flatwise—this being done so that the cilia may afterward fall out. Then the upper lid is denuded by first making the intermarginal section in the same way as upon the lower lid and then ablating the bed of hair follicles thus detached. There is thus produced a raw surface, to which it is intended that the skin flap of the lower lid shall adhere by its raw surface. In order that adhesion of the raw surfaces themselves, and not simply of their edges, shall take place, the suture is applied as follows: Both ends of a thread armed with a needle at each end are carried through the upper lid near its free border, the needles being passed from behind forward. In this way the loop of the thread gets to lie upon the conjunctival side of the lid, while the free ends come out upon the raw anterior surface. These ends are then passed through the base of the skin flap below and are tied upon its anterior aspect over a glass bead. By this suture the base of the flap is kept pressed against the raw surface of the tarsus of the upper lid; then, as an additional precaution, the edges of the skin flap are accurately united to the edge of the wound in the upper lid by means of a few fine sutures. The adhesion of the lids obtained by this method is firm enough to withstand even a powerful strain."

The eye should be kept under a bandage for a few days and the sutures should be allowed to remain for nearly a week.

PTOSIS

Ptosis is a drooping of the upper eyelid. It may be congenital or acquired. Spontaneous cure does not occur in the congenital variety. Acquired ptosis is usually unilateral and most often results from either traumatism or syphilis. No case of ptosis should be operated upon until it has been determined that restoration of the function of the levator palpebræ cannot be accomplished through medicinal treatment. A large number of operations have been devised for relief of this condition but none of them is absolutely satisfactory. Most of these operations depend for their effect upon either removal of tissue from the lid, or transference of the function of the paralyzed levator to the occipitofrontalis or the superior rectus, or resection or advancement of the levator palpebræ superioris. If the ptosis is small in amount (2 or 3 mm.), probably the best results can be obtained through resection of the tarsus (page 68. If the drooping is considerable in amount, one of the operations depending upon the attachment of the upper lid to the frontalis tendon will be found moderately satisfactory.

Tansley-Hunt Operation for Ptosis.—One of the most satisfactory operations for a large amount of ptosis is the Tansley-Hunt modification of the Panas operation. With this procedure the upper lid is attached to the tissues of the eyebrow and depends for its elevation upon the action of the frontalis muscle. A horizontal incision 1/4 in. (6 mm.) in length is made at the orbital margin above. Parallel vertical incisions are carried down nearly to the lid margin and a strip of skin is dissected up. Triangular pieces of skin are removed from each side of the strip in front of the tarsus, and a short incision is made just above the eyebrow, and the skin is undermined down to the horizontal incision at the orbital margin. (Fig. 87). A narrow strip of skin is then drawn through the tunnel just made and sutured. Enough silk sutures are introduced to bring the skin flaps into apposition (Fig. 88). It is well to scrape the epithelial surface of the skin flap before drawing it under the eyebrow. This insures good union. In most cases of ptosis the occipitofrontalis is over-developed, and reasonably good action of the eyelid is obtained by making use of this muscle.

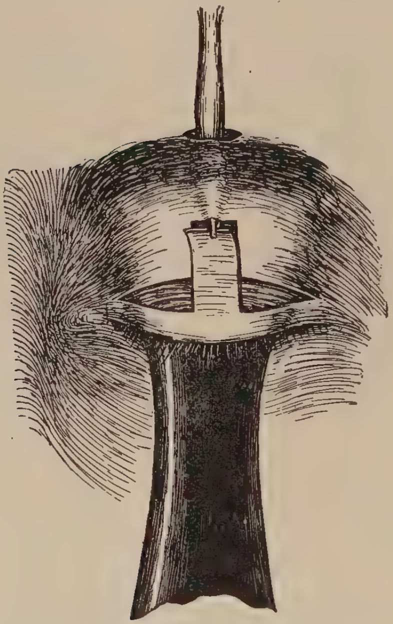


FIG. 87.—TANSLEY-HUNT OPERATION FOR PTOSIS.

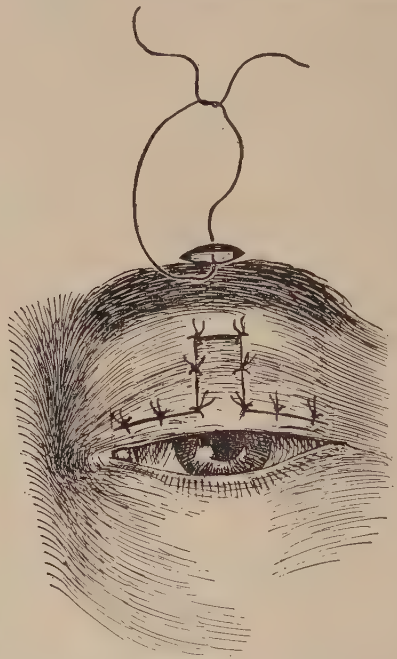


FIG. 88.—TANSLEY-HUNT OPERATION FOR PTOSIS. Sutures introduced.

Resection of the Tarsus.—INSTRUMENTS.—Ehrhardt lid forceps, mouse-tooth forceps, scalpel, fine curved dissecting scissors, needle-holder, and 3 double-armed silk sutures. In place of the Ehrhardt forceps the operation may be performed less conveniently by using a horn or rubber plate and fixation forceps.

ANESTHESIA.—Injection of cocain and adrenalin into the tissues of the lid is satisfactory except in cases in which the eye is in a painful or irritable condition. In order to make the operation painless, it is necessary to inject the solution into the tarsus itself as well as into the soft tissues of the lid. This can be accomplished by entering the tarsus with the hypodermic needle through the conjunctival surface as well as through the skin. If general anesthesia is employed, adrenalin solution should be injected to control the hemorrhage.

OPERATION.—Apply the forceps to the upper lid with the plate in contact with the skin and the serrated edge in contact with the conjunctiva about 2 mm. from the margin, and evert the lid. Make an incision through the conjunctiva and tarsus 2 to 3 mm. from the border of the lid throughout the entire length of the tarsus (Fig. 89). In doing this, it is important that the incision should not be carried into the orbicularis muscle as a brisk hemorrhage is liable to result from cutting the arteries that lie in this tissue. If the incision is carried through the tarsus and no further, very little bleeding will occur throughout the operation.

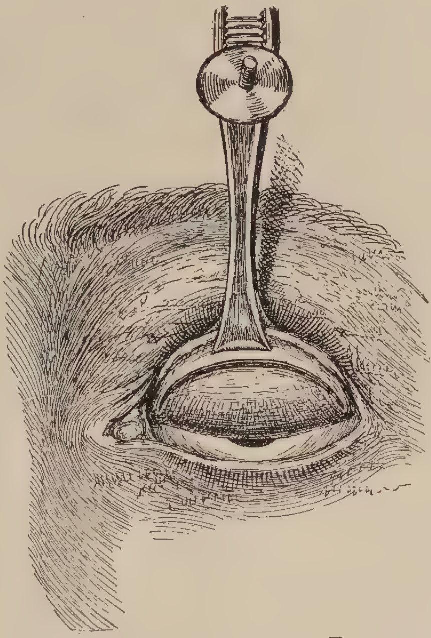


FIG. 89.—RESECTION OF THE TARSUS OF UPPER LID OF LEFT EYE. Lid is held in eversion with Ehrhardt forceps. Incision through conjunctiva and tarsus has been made.

Now divide the loose tissue between the orbicularis and tarsus and cut the tarsus with its conjunctival lining free at its curved upper margin. If the operation is being performed for a ptosis of slight amount, it may be wise to leave a strip of the upper part of the tarsal cartilage.

While the lid is still everted, introduce 1 of the 2 needles in each double-armed suture into the edge of the conjunctiva and tendon of the levator palpebræ superioris and place the needles carefully on a sterile towel on the face. One of these sutures should be in the middle and the other 2 equidistant from the middle and ends of the wound. Care should be taken not to allow these sutures to become crossed or twisted (Fig. 90).

Next remove the lid forceps and allow the eyelid to assume its normal position. Carry the upper needle on each suture through the orbicularis and skin of the eyelid just above the tarsal rim at the margin of the eyelid and the lower needle through the entire thickness of the lid, including the conjunctiva and tarsus just below the cut edge of the tarsal rim. This will bring the edge of the conjunctiva and levator tendon down to the cut edge of the marginal rim without causing overlapping and the sutures will cause no irritation to the eyeball. The sutures should be tied over a roll of gauze which lies on the skin of the lid (Fig. 92). A dressing may be kept on for 2 or 3 days and the sutures may be removed the sixth day.

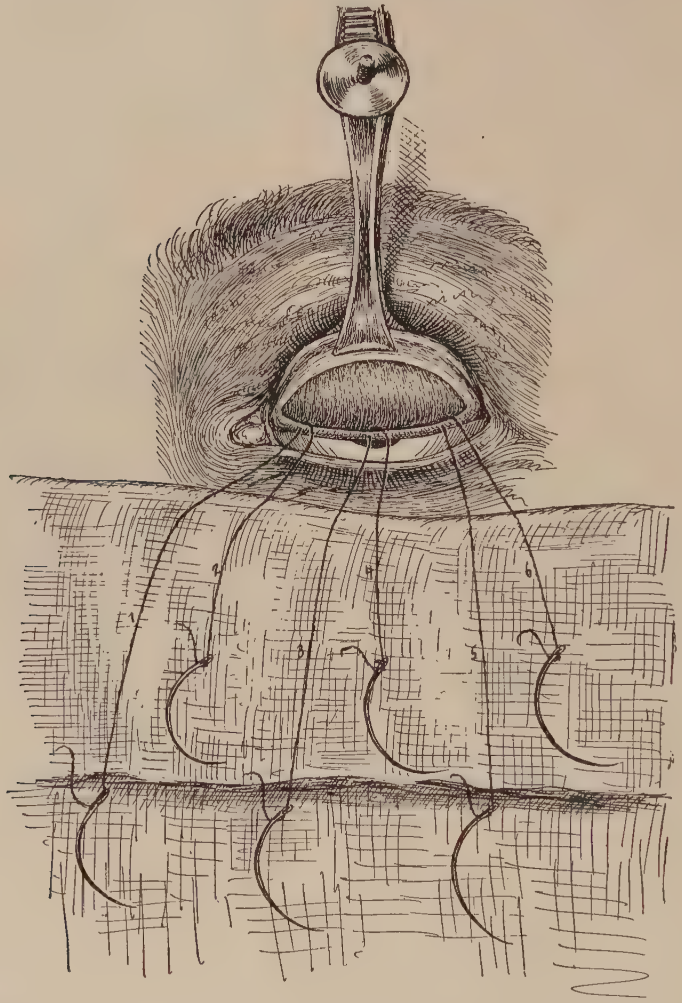


Fig. 90.—Resection of Tarsus, Showing Sutures in Conjunctival Margin After Removal of Tarsus.

In old trachoma cases this operation will usually correct the accompanying trichiasis and ptosis as well as remove the trachomatous tissue.

SYMBLEPHARON

By the term *symblepharon* is meant a condition in which the conjunctival surfaces of the eyelid and eyeball become firmly adherent to each other. The lower lid adheres to the globe more commonly than the upper. Symblepharon results usually from burns by acids, caustics or hot metal, or from traumatism. The position and extent of the adhesions determine the nature of the operation. If the adhesion is small and near the lid margin, severing it and closing the conjunctival wound of the globe with fine silk sutures may suffice. Free anointing with vaselin should be kept up for several days to prevent reattachment of lid and eyeball.

May-Hotz Operation.—This is a skin grafting operation for the more severe cases of symblepharon. The eyelid is cut free from the globe with scissors, and the cicatricial tissue is removed. A plate of lead or other material is cut and shaped to fit and an aperture is made for the cornea. The plate may be covered with paraffin if the surgeon chooses. Thiersch grafts are taken from the inner side of the arm and placed over the edge of the plate with the raw surface outward, in such a way that the denuded area on the lid and eyeball will be entirely covered with skin. With the grafts clinging to it, the plate is put in position inside the eyelids. Sutures are introduced to hold the lid margins together for a few days. The plate may be removed in 5 days. It is well to keep the eye under dressing and bandage for a week. Permanent cure of symblepharon should result, but sometimes a part of the grafted skin on the eyeball shows and the cosmetic effect is not pleasing.

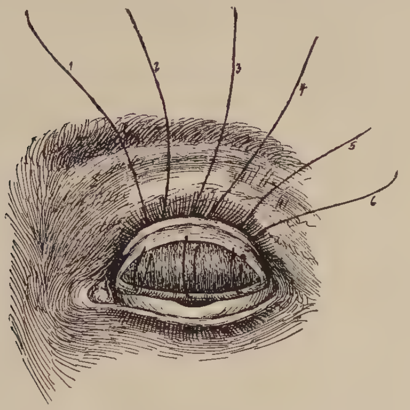


Fig. 91.—Resection of Tarsus. Sutures have been carried through the lid.

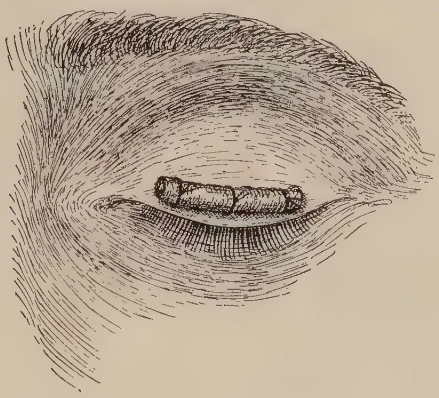


Fig. 92.—Resection of Tarsus. Sutures tied over roll of iodoform gauze.

RESTORATION OF THE CUL-DE-SAC

Weeks describes this operation as follows:

> "For restoring the culs-de-sac in case of their obliteration (contraction of the orbit), with absence of the globe, the so-called Wolff graft has been very successful in the author's hands. The surface from which the graft is to be taken should supply a suitable quality of skin. This can be obtained from the inner surface of the arm, forearm, or inner surface of the thigh. The surface should be prepared some hours before, so as not to lose time during the operation.

"**Preparing for Reception of Flap.**—To obtain sufficient room to operate readily, the outer canthus may be extended to the margin of the orbit by a free canthotomy; this is not necessary in all cases. The lid should be dissected from the orbital tissue, including with it only the tarsus and orbicularis palpebrarum muscle. If much tissue is dissected away with the lid, the result will be a lid that is too thick. Should there be considerable conjunctiva, the incision through it should be so made that the greater part of the conjunctiva will serve to cover the orbital stump. It is better to leave but a very narrow strip of conjunctiva attached to the margin of the lid. The lid is detached until the groove between lid and orbital tissue extends to the tissue immediately above the periosteum at the margin of the orbit. The groove should extend from the inner canthus to the outer commissure, connecting with the incision which has been made to prolong the palpebral fissure. Cicatricial tissue may require removal but is usually not sufficient in quantity.

"After completing the groove, the plate to be employed should be fitted. The plate may be conveniently made of the flexible rubber used by dentists, termed 'base-plate gutta-percha.' By dipping in hot water, the piece to be used may be made to assume the desired shape, and if while the shape is maintained the rubber is dipped in cold water, the shape will be fixed. The rubber may be cut any size by means of scissors, and the edge made perfectly smooth by treating it with a hot strabismus hook or similar instrument, having first applied some vaselin or oil to the edge to be so treated. The shell should be made sufficiently large to completely fill the pocket. If there is no pocket in the upper lid in which the upper edge of the shell can be lodged until the time for making an upper cul-de-sac arrives, a shallow groove may be cut in the tissues immediately back of the margin of the upper lid.

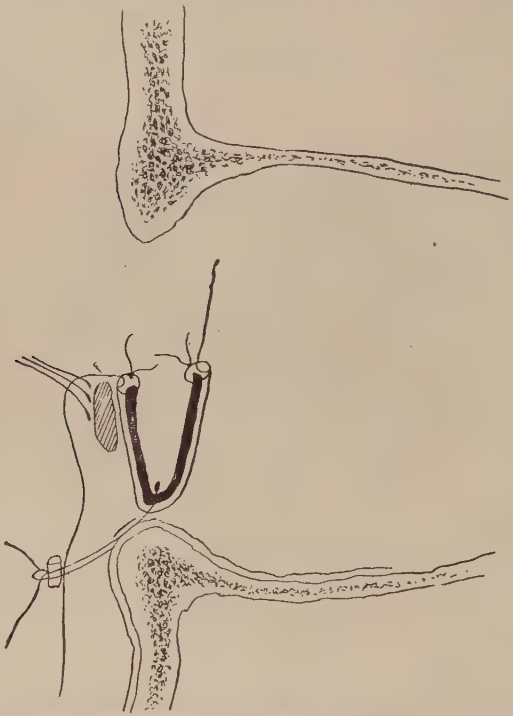


FIG. 93.—RESTORATION OF LOWER CUL-DE-SAC. Cross section, showing flap in position, sutured to lid, periosteum at orbital margin, and to orbital tissue. (After Weeks.)

"In preparing the upper cul-de-sac the dissection should correspond with the dissection for the lower cul-de-sac, except that before reaching the periosteum the tendon of the levator palpebræ superioris must be cut across.

"After having completed the groove, it is packed with pledgets of absorbent cotton moistened with normal saline solution, and the lids are covered with a pad dipped in the saline solution.

"**The Flap.**—The flap should have an area about one-half larger than the surface to be covered as it is marked out on the surface from which it is to be removed. The size of the flap may be measured, and its boundaries indicated by pricks made with a needle or with the point of a Graefe knife. The punctures bleed slightly, plainly indicating the boundary. With a very sharp, small scalpel, or a cataract knife, an incision barely through the skin, which is rendered slightly tense by an assistant, is carried around the entire flap. The edge of the knife is now directed toward the center of the flap and the margin of the flap throughout its entire extent is undermined for a distance of two or three millimeters. The subcutaneous tissue is not included in the flap. The edge of the flap is seized with broad fixation forceps and by means of a small, very sharp knife (Beers, Graefe knife, or scalpel), the skin is separated from the underlying areolar connective tissue. As soon as the flap is dissected away sufficiently it is seized between the thumb and forefinger and the dissection is continued, cutting at the junction of skin and subcutaneous tissue, which can now be quite distinctly seen. The flap is detached as quickly as possible. After removal the flap is folded so that the epithelial surfaces are in apposition. Three double-armed sutures are passed through the flap at the bottom of the groove formed between the two layers of the flap, the needles of one suture being so passed that a loop two millimeters in length falls on the cutaneous surface at the center of the flap, and one about ten millimeters each side of the center of the flap.

"**Adjustment of Flap.**—The flap contained in the moistened gauze is placed on the brow near the wound if the lower lid is being operated upon (on the cheek if the upper lid is being operated upon), and the double sutures (which have been made sufficiently long) are passed through the tissue at the apex of the groove through the periosteal tissue at the margin of the orbit, and are made to emerge on the skin of the cheek just below the margin of the orbit, the position of the sutures corresponding to their position in the flap. The threads of each suture are passed parallel to each other. After the needles of all the sutures have been passed, traction is made on all of the sutures uniformly, and the flap, freed from the gauze which contained it, is drawn into position in the groove. The sutures are now tied over small rolls of iodoform gauze placed on the skin of the cheek (or brow). The traction made is just sufficient to hold the flap firmly in contact with the tissues at the bottom of the groove. The margins of the flap are now attached by small interrupted sutures to the margin of the lid and the margin of the mucous membrane or other tissue of the orbital stump, so as to completely cover the denuded area. If much excess of flap is present, it should be trimmed off, but the flap should be sufficiently large to prevent traction at any point.

"**Insertion of Plate.**—After having secured the flap, the plate must be placed in the cul-de-sac and there maintained until the cul-de-sac is ready for the reception of the artificial eye. Before insertion the plate should be thoroughly sterilized by washing and treating with alcohol and bichlorid solution. A lubricant in the form of bichlorid vaselin (1:5,000) is applied to the plate before it is slipped into position. The plate should not be large enough to exert great pressure on the flap at the base of the cul-de-sac, but it should fit snugly.

"**Subsequent Treatment.**—The lids are now properly adjusted and are covered with a small piece of rubber tissue which may be smeared with the vaselin. The piece of rubber tissue should be notched at the sides so that any secretion that may form can escape from the wound into the dressings, at the inner and outer canthi. Iodoform gauze, plain absorbent gauze, and absorbent cotton are placed above the rubber tissue and a bandage applied. Unless unfavorable symptoms arise the bandage is not disturbed for three or four days. The eye is then inspected and if there is no evidence of infection a similar bandage is applied and is not disturbed for three days. The flap can then be inspected. If everything goes well, it is best to permit the plate to remain for ten days or two weeks before removing it. If there should be evidence of inflammation, it may be necessary to remove the plate to cleanse the parts, after which the plate should be again inserted.

"The periosteal sutures should be permitted to remain in place until they become somewhat loosened—usually from six to ten days. The stitches that unite the flap to the tissues of the lid and orbit may be removed at the end of a week or on first removal of the plate.

"As the healing process advances, some shrinkage of the flap occurs, necessitating a slight reduction in the size of the plate. Shrinkage usually begins from ten days to two weeks after the operation, and continues, ordinarily, for about three months. It is necessary to keep the plate or an artificial eye in situ until the shrinkage has ceased, removing the plate or shell every four to seven days for the purpose of cleansing. An artificial eye can ordinarily be worn three weeks after the operation. The flap does not become modified greatly in character by its retention in the orbit, but the functions of the skin are preserved to some extent, and in many cases an abnormal growth of hair takes place. In rare cases an odor develops, apparently due to the growth of some species of micro-organism. This can be corrected by treating the parts with a solution of the chlorate of potash, or 60 per cent. alcohol in which mercuric chlorid in a strength of 1 to 2,000 has been dissolved."

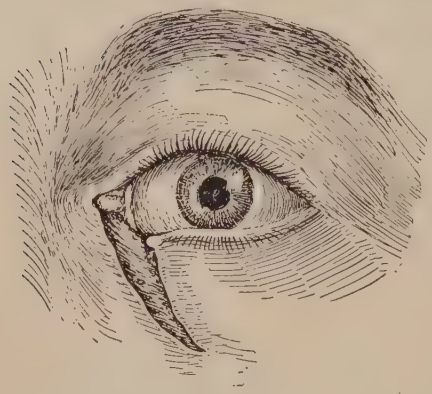


Fig. 94.—Characteristic Wound of Lower Lid of Left Eye.

INJURIES TO THE EYELIDS

The tissues of the eyelid usually heal readily, and fortunately there is little tendency toward spread of infection, even if a wound of the lid shows purulent discharge.

Superficial wounds of the lids usually need nothing more than cleansing and coaptation with skin sutures. If a wound extends through the entire thickness of the eyelid, very careful adjustment is necessary, or deformity may result. This may be of more than cosmetic importance as resultant exposure of the cornea might lead to impairment of vision or to the loss of the eye through ulceration. Tears or cuts through all the layers of the eyelid call for careful suturing of the conjunctiva as well as the lid margin and skin. A rather common and a very important tear is one which starts near the inner canthus in the lower lid and passes through the canaliculus, and follows the direction of the orbicularis fibers near the margin of the orbit. There is a strong tendency for the flap that has been torn loose to heal in a position too low and not close enough to the

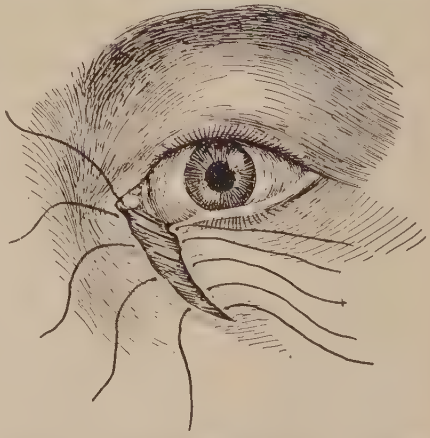


Fig. 95.—Characteristic Wound of Lower Lid. Sutures introduced to hold temporal flap in position of overcorrection.

eyeball, so that an ectropion results, with inability to close the lids properly. In adjusting such a wound it is important that the angle of the flap be carried upward and backward to a point of overcorrection. To accomplish this, after suturing the conjunctiva with fine silk, introduce heavier silk sutures (No. 5) through the skin in a diagonal direction as shown in the accompanying illustration (Fig. 95), and apply a gauze dressing with pressure bandage. The sutures should be allowed to remain for 6 or 7 days.

A similar wound occurs less often in the upper lid, and the flap should be handled in a corresponding manner.

Foreign bodies sometimes lodge in the eyelid. Usually it is easy to locate them with the fingers, so the X-ray does not have to be used. The simplest way to extract them is to cut down on them through the skin, and remove them with forceps and scissors. Even in the case of magnetic foreign bodies such as iron or steel, the electromagnet usually offers no advantage in their extraction.

OPERATIONS ON THE LACRIMAL APPARATUS

SURGICAL ANATOMY OF THE LACRIMAL APPARATUS

The *lacrimal gland* has two portions: a main or orbital lobe, and an accessory or palpebral portion. The orbital portion of the gland lies in contact with the periosteum in the lacrimal fossa, a shallow depression just behind the margin of the orbit where the roof and outer wall meet. Several small ducts carry the lacrimal secretion (tears) to the conjunctiva where it folds over from the eyeball to the eyelid in the outer, upper part. Surrounding these ducts is the palpebral or accessory lobe of the gland. The lacrimal secretion moistens the eyeball and is carried down into the inferior meatus of the nose through the canaliculi, lacrimal sac and nasal duct, when this drainage apparatus is in normal condition.

There are 2 *canaliculi,* one in the upper lid and one in the lower. Each canaliculus has a minute opening in the lid margin about 5 mm. from the inner canthus, which lies in contact with the conjunctiva of the eyeball. The course of the canaliculi is important. The lower passes downward from the punctum a distance of 1 to 2 mm., and the upper passes upward the same distance, and then the two converge to join at the lacrimal sac, near its upper end, behind the canthal ligament, which is really the tendon of insertion of the orbicularis muscle.

The *lacrimal sac* is the dilated upper end of the nasal duct which lies in the lacrimal groove. The upper end of the sac is called the dome, and the lower end the neck. The *nasal duct* is about 18 mm. (¾ in.) long, and takes a direction downward, and slightly backward and outward to its valve-like opening in the nose. The lacrimal sac lies in the *lacrimal groove,* the anterior part of which is formed by a portion of the firm superior maxillary bone, and the posterior part by the lacrimal bone, which is of a thin and very delicate structure. The groove is limited in front by the anterior crest, which is the continuation of the orbital margin, and behind by the posterior crest, a less prominent ridge in the lacrimal bone. To the nasal side of the sac wall is periosteum, which lines the groove, and to the temporal side and in front is deep fascia, which is attached to the anterior crest in front, and to the posterior crest of the groove behind.

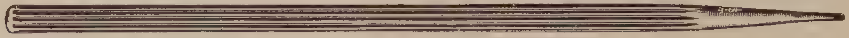


Fig. 96.—Punctum Dilator.

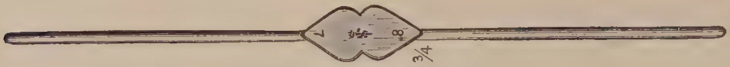


Fig. 97.—Bowman Probe.

The tissues in front of the lacrimal sac are skin, superficial fascia, orbicularis muscle, canthal ligament, and deep fascia. The angular artery passes in a vertical direction a few millimeters in front of the sac, and the angular vein accompanies it. If these vessels are cut a brisk hemorrhage results. The dissections for removal of the sac should all be posterior to them.

PROBING

When there is stricture of the canaliculus or nasal duct, an attempt is sometimes made to dilate with probes. Lacrimal probing is unpleasant for the patient, often difficult to perform, and usually unsatisfactory in results. Early in the course of a chronic dacryocystitis, in conjunction with irrigation, systematic probing sometimes is beneficial. In congenital stoppage of the canaliculus or duct, the single passage of a small probe is usually all that is necessary. Bowman's silver probes (Fig. 97) are satisfactory, but somewhat

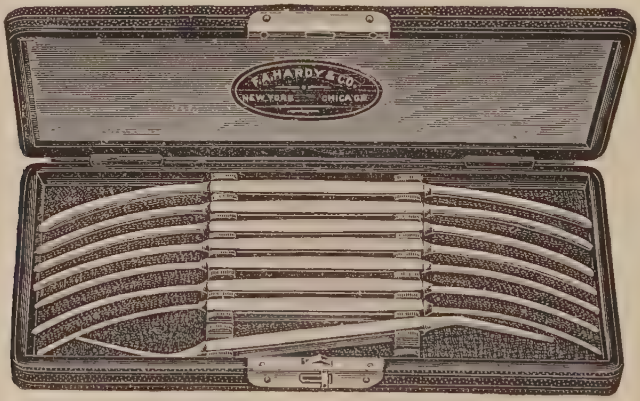


Fig. 98.—Weidler's Probes.

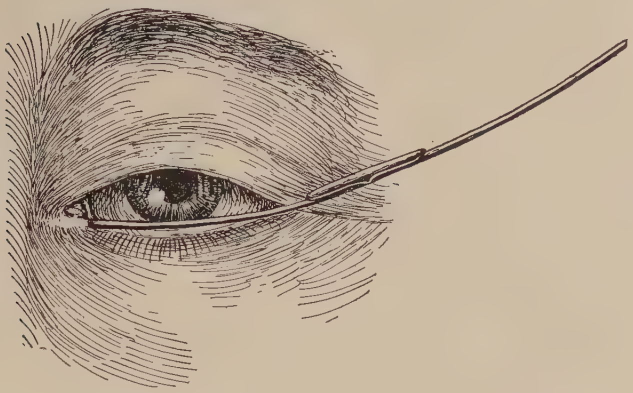


Fig. 99.—Lacrimal Probe in Lower Canaliculus.

awkward to handle. Weidler, of New York, has recently introduced a set of probes (Fig. 98) with a handle which is easy to hold and manipulate.

To pass the probe have the patient in either the lying or sitting posture, and stand behind the patient's head. With the thumb of one hand manipulate the lower lid, and with the other hand pass the probe, carefully following the

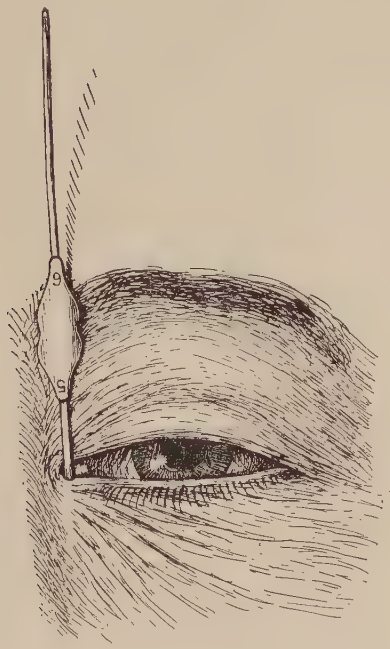


Fig. 100.—Lacrimal Probe in Nasal Duct.

course of the lacrimal passage. Probing is usually performed through the lower canaliculus. With the punctum slightly everted by the thumb, the probe is carried in a vertical direction 1 or 2 mm.; then the lower lid is put well on the stretch in an outward direction, and the probe is cautiously carried into the lacrimal sac in a direction inward and slightly upward—almost horizontal. If the end of the probe is resting against the mucous membrane lining the nasal wall of the sac, as it should, there is no tendency for it to spring back; it feels firm. Now, if the surgeon wishes to pass the probe through the nasal duct he releases his hold on the eyelid and swings the probe into a nearly vertical position, and carefully pushes it down into the nose.

IRRIGATION

For irrigating the lacrimal passage an Anel syringe or some other good lacrimal syringe and a mild antiseptic and astringent solution should be used. Solutions containing silver or lead should not be employed, as disfigurement from staining of the tissues may result. Several cases of argyrosis of the tissues of the eyelids have been reported from escape of argyrol into the tissues, resulting from attempts to medicate the lacrimal passage. The syringe should be used very gently, with no attempts to force the solution.

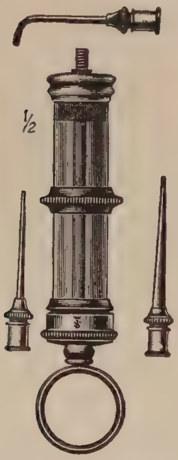


Fig. 101.—Lacrimal Syringe.

SLITTING THE CANALICULUS AND LACRIMAL DUCT

This operation is performed less frequently than formerly to cut strictures of the duct, as the benefit derived from it is only temporary. Sometimes an acute dacryocystitis can be aborted by opening up the nasal duct by this operation. It may be done under either local or general anesthesia; gas is satisfactory for adults. If local anesthesia is used cocain and adrenalin solution should be injected into the sac after dilatation of the canaliculus. The probe pointed knife of Agnew or Weber should be used.

The lower lid is everted and the knife enters the punctum in a vertical direction. The lid is stretched away from the tendo oculi and held in a position of slight eversion, while the probe point of the knife is carried into the sac with the cutting edge directed upward and backward so that the incision will come in contact with the conjunctiva of the globe when the lid is released. Make sure that the end of the knife is in contact with the interior of the nasal wall of the sac by moving the knife toward the nose and away from it very slightly and very gently. If the tissues at the inner canthus do not move with the knife in this slight movement it has entered the sac. After assuring himself that the probe point of the knife is inside the sac wall the surgeon raises

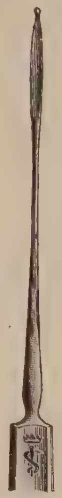


Fig. 102.—Agnew's Canaliculus Knife.

the handle of the instrument until the blade is made to assume a vertical position. The knife is then carried through the duct with the cutting edge directed forward. Incisions can be made in other directions by turning the handle of the knife and carrying the knife up and down in the duct. Then the knife is withdrawn and a Bowman probe, No. 8 or 10, is passed into the duct and allowed to remain there for a few minutes. After removing the probe the sac and duct may be irrigated with a lacrimal syringe containing boric acid solution.

EXTIRPATION OF THE LACRIMAL SAC

INDICATIONS.—This operation is for cases of chronic dacryocystitis which do not yield to the less radical procedure of probing and irrigating. It should be done in all cases of diseased lacrimal sac in which an intra-ocular operation is to be performed on the corresponding eye, in cases of lacrimal fistula which refuse to heal, those in which the sac wall has become decidedly dilated or thickened, and in malignant diseases of the sac. The results from this operation are eminently satisfactory. The cause of the pus formation is entirely removed and the epiphora is reduced.

INSTRUMENTS.—A hypodermic syringe, small scalpel, mouse-tooth forceps, splinter forceps, small curved scissors, Müller's speculum, No. 8 Bowman probe, small curet, needleholder and silk sutures.

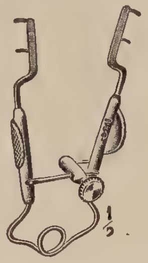


Fig. 103.—Muller's Lacrimal Sac Speculum.

INJECTION.—If the operation has to be done under general anesthesia a solution of adrenalin 1:4,000 may be used to control the hemorrhage. The operation may be performed under local anesthesia almost without pain. A reliable solution for injection is made up of cocain 4 per cent. one part, adrenalin 1:1,000 one part and distilled water two parts.

Superficial injection is made under the skin along the anterior crest of the lacrimal groove. The deep injection into the tissues is made by entering the hypodermic needle 4 mm. above the inner canthus and carrying the point of the needle straight back to the tissues above the dome of the sac. The distance which the point of the needle should penetrate must be governed by the character of the tissues about the sac. In an emaciated subject with no inflammatory thickening, the dome of the sac is very near the skin. In a well nourished individual with thickening of the tissues, due to dacryocystitis, the distance from the skin to the dome of the sac may be 2 or 3 times as great as in an emaciated patient. On an average, the needle point should penetrate about ¼ in. (6 mm.). The needle is now made to enter the neck of the lacrimal sac by piercing the skin at the junction of the lower orbital margin and the anterior crest of the lacrimal bone and carrying the needle in a direction downward, backward, and inward. As the solution from the syringe is pressed into the sac it usually displaces whatever secretion may be within the sac cavity, and this secretion together with cocain and adrenalin solution is forced through the canaliculus. The solution within the lacrimal sac anesthetizes and blanches the canaliculi, the mouth of the nasal duct, the sac wall and all of the tissues surrounding it, and further deep injection is unnecessary. The operation may be started immediately on completion of the cocain and adrenalin injection.

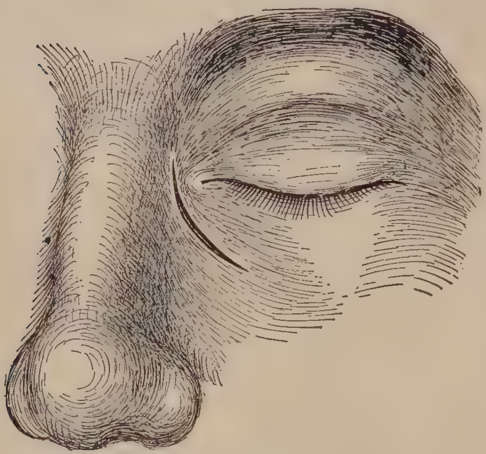


Fig. 104.—Extirpation of Left Lacrimal Sac. Primary incision.

PRIMARY INCISION.— This should start 3 mm. above the canthal ligament (tendo oculi) and 3 mm. to the nasal side of the inner canthus and should be carried down along the anterior crest of the lacrimal groove to the mouth of the duct (along the whole length of the anterior crest of the lacrimal groove, Fig. 104).

DISSECTION.—The skin is dissected with the tooth forceps and scissors away from the canthal ligament, where it is quite adherent, and from the orbicularis muscle above and below the ligament, enough so that the speculum of Müller may be introduced. It is well to adjust the upper teeth of the speculum first and to spring the wound well open before setting the speculum.

Next the *canthal ligament* is thoroughly exposed by passing the closed points of the scissors firmly along the upper and lower margins of the ligament in a direction parallel to its fibers. (Fig. 105.) The ligament is cut about 2 mm. from its nasal end in a direction backward and inward. Then the *orbicularis fibers* are divided along the anterior crest from the upper to the lower end of the primary incision. This exposes to view the deep fascia which directly surrounds the lacrimal sac. Pointing the scissors backward and inward, cut through the *deep fascia* immediately behind the stump of the can-

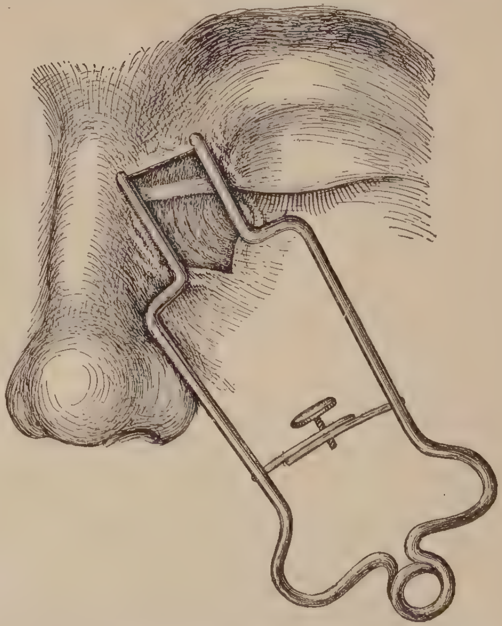


Fig. 105.—Extirpation of Lacrimal Sac. Internal canthal ligament and orbicularis palpebrarum muscle exposed.

thal ligament. This exposes the anterior wall of the lacrimal sac. This is of a different color and of less firm consistency than the tough fascia which surrounds it. Divide the fascia along the whole length of the anterior crest of the lacrimal groove. When properly made, the incisions in the orbicularis muscle and the deep fascia should be as long as the primary incision in the skin and directly behind this incision. Extirpation is often rendered unnecessarily difficult by incomplete exposure of the sac. If these incisions have been properly made there will be a tendency for the deep fascia to separate from the sac wall (Fig. 106). Pick up the deep fascia with the mouse-tooth forceps and dissect it away from the sac wall by gently moving the closed points of the scissors up and down in contact with the deep fascia, but taking care not to pierce the fascia and so go out of bounds. Resistance to this dissection will be met with where the canaliculi join the lacrimal sac, or, in other words, at the ampulla, and this may be snipped through with the scissors. The dissection should be carried back to the posterior crest of the lacrimal groove.

Up to this point the sac has remained attached to the *periosteum* lining the groove, and is especially adherent along the anterior and posterior crests, and at the dome and neck of the sac. If there is a slight shelf of deep fascia overhanging the sac along the anterior crest this may be divided behind the stump of the ligament. In order to facilitate starting the detachment of the sac from the periosteum, grasp the sac by taking a good bite of the wall with the forceps, and make gentle traction away from the periosteum. Then by careful manipulation the delicate fascia between the sac wall and periosteum is dissected by running the scissors lengthwise of the lacrimal groove and snipping along the anterior crest and wherever else may be necessary. Carry this dissection from the dome of the sac to the mouth of the duct. Next grasp the upper portion of the sac wall and cut it free from the adherent tissues at the dome. Lift the sac wall gently out of the cavity and divide the adhesions along the posterior crest with the scissors. Then pull it gently upward so as to put the neck on the stretch and free the lower end completely from the adherent tissues that surround it. Keep the traction on the sac in an upward direction, straddle the mouth of the duct with the blades of the

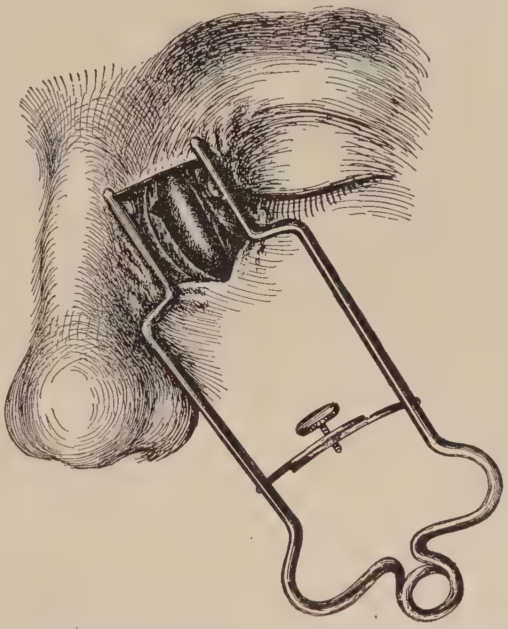


FIG. 106. — EXTIRPATION OF LACRIMAL SAC. Canthal ligament has been cut and incision in deep fascia has been made exposing lacrimal sac.

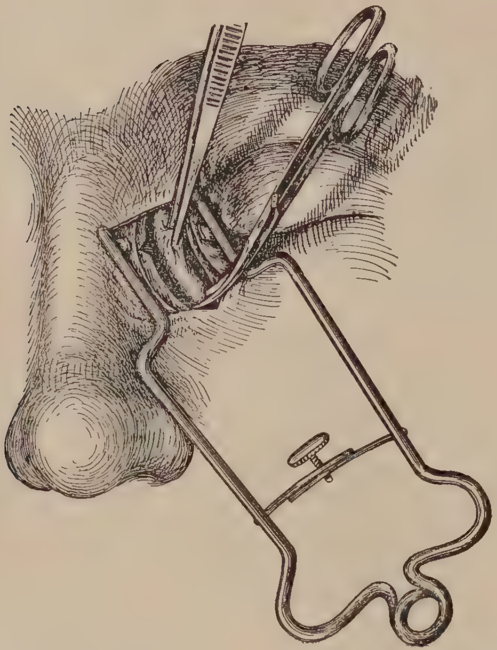


Fig. 107.—Extirpation of Lacrimal Sac. Lacrimal sac has been dissected free from periosteum and deep fascia. Held in forceps ready to cut off at neck.

scissors, and cut it off as low as possible (Fig. 107). If the surgeon has been successful in removing the lacrimal sac in its entirety, it will not be necessary to use the curet, nor is it essential that the probe be entered into the nasal duct.

The cavity should be irrigated with boric acid solution, and if the operator chooses he may swab it out with tincture of iodin.

SUTURING.—In sewing up the wound it is good practice, but not necessary, to sew up the canthal ligament. A fine gut suture may be introduced to bring the cut ends of the ligament in apposition or the ligament may be included with the skin suture. Introduce the skin sutures in such a manner that the temporal flap will be slightly raised, as the tendency following this operation will be toward ectropion and proptosis of the lower lid, especially if there has been a fistula, and inflammatory tissue has had to be removed (Fig. 108).

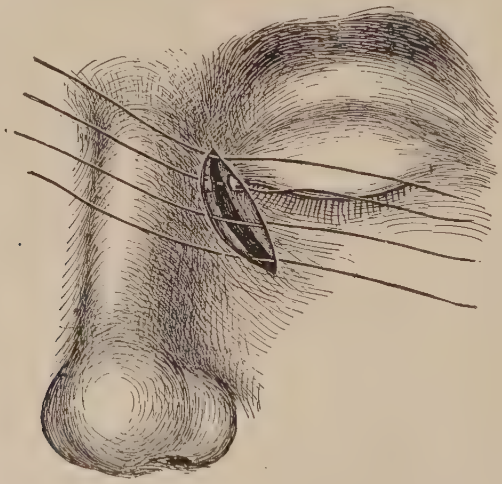


Fig. 108.—Extirpation of Lacrimal Sac. Sutures introduced ready to tie.

AFTER-TREATMENT.—Bichlorid vaselin is smeared on the wound, and iodoform gauze dressing and pressure bandage are applied. The first dressing is left on for 2 days after operation. The sutures are removed 4 or 5 days following operation.

If annoying overflow of tears persists after the removal of the lacrimal sac, the palpebral portion of the lacrimal gland may be resected.

EXCISION OF THE PALPEBRAL PORTION OF THE LACRIMAL GLAND

ANESTHESIA.—This operation may be done under local anesthesia by cocain and adrenalin injection, but it is better to put the patient under general anesthesia, as there are considerable hemorrhage and pain under local injection. If performed under general anesthesia, an injection of 1:4,000 adrenalin should be made in and about the gland through the conjunctiva. For local anesthesia an injection of adrenalin 1:1,000 one part, cocain 4 per cent. one part, and distilled water two parts is used.

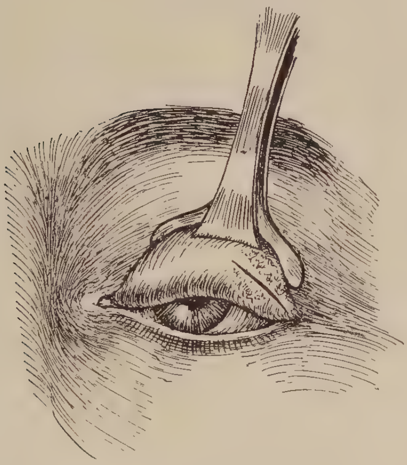


FIG. 109. — RESECTION OF PALPEBRAL PORTION OF LACRIMAL GLAND. Conjunctival incision.

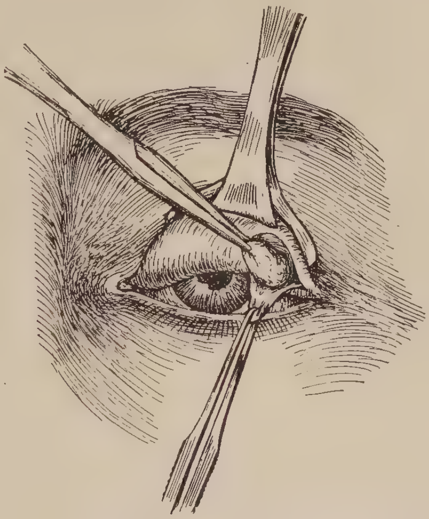


FIG. 110.—RESECTION OF PALPEBRAL PORTION OF LACRIMAL GLAND. Dissection almost completed.

It may be considered good surgery to resect the palpebral portion of the lacrimal gland in all cases of extirpation of the lacrimal sac which are done under general anesthesia.

OPERATION.—The lid should be held in double eversion. This is best accomplished by the use of the Ehrhardt lid forceps. It may be held less conveniently by the use of a bone spatula and fixation forceps. Make an *incision* extending from the outer canthus toward the inner canthus about ½ in. in length (Fig. 109). As a rule, the position of the gland can easily be detected by a rounding elevation which presents itself on everting the lid. On completing the conjunctival incision the thin capsule surrounding the palpebral portion of the gland comes into view and the conjunctiva is readily separated from this membrane. Grasp the gland with the fixation forceps and dissect out carefully with the scissors (Fig. 110). In excising this portion of the gland the ducts which are embedded within it are resected, and the result of this operation in reducing epiphora is due more to the resection of these ducts than to the removal of the gland tissue proper. The conjunctival wound is closed with 2 or 3 fine gut sutures. Excessive dryness of the eye does not occur following this operation.

OPERATIONS ON THE ORBIT

SURGICAL ANATOMY OF THE ORBIT

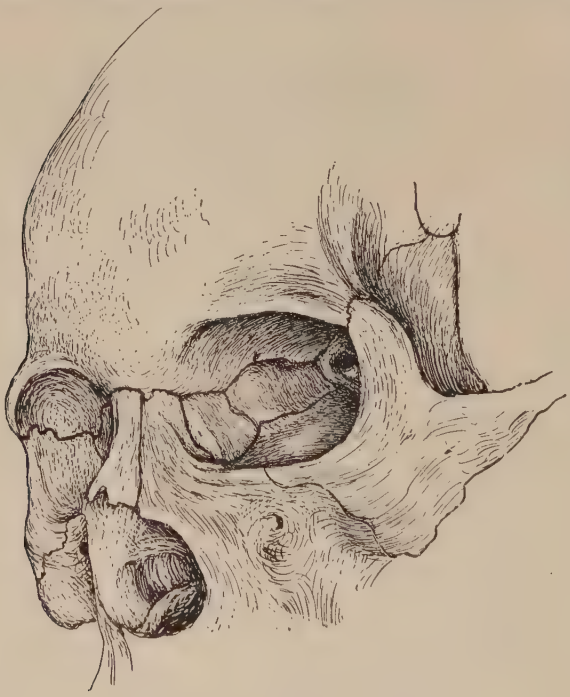


Fig. 111.—Left Bony Orbit.

The orbit is a bony cavity for the lodgment of the eyeball, with its muscles, nerves, vessels, and fascial attachments, lacrimal gland, lacrimal sac, and orbital fat. In shape it is an imperfect pyramid, with a depth of from 4 to 4½ cm., with its apex at the optic foramen and its base at the orbital margin. The axes of the orbital cavities diverge, so that the inner walls of the two cavities are practically parallel.

The *roof* is formed largely by the orbital plate the frontal bone. A small portion of the roof at the apex is formed by the lesser wing of the frontal bone. A small the frontal sinus is a part of the anterior portion of the roof of the orbit. These 2 cavities are separated by only a thin plate of bone.

The *nasal wall* of the orbit is formed by a small portion of the nasal process of the superior maxillary bone, lacrimal bone, os planum of the ethmoid, and body of the sphenoid. The lacrimal bone and os planum of the ethmoid separate the orbital cavity from the ethmoidal cells and are very thin, sometimes even perforated.

The *floor* of the orbit slants downward and outward from its inner border. It is formed largely from that part of the superior maxillary bone which covers over the maxillary antrum (antrum of Highmore). A small portion of the malar bone enters into the formation of the anterior part of the floor, and the orbital process of the palate bone forms a small part of the floor at the apex.

The *external wall* runs from the apex forward and outward to the orbital margin. It is formed from the greater wing of the sphenoid and the malar bone. It is comparatively thick and protective in character and separates the orbital cavity from the temporal fossa which lodges the temporal muscle.

The *orbital margin* is heavy and prominent and is made up of the frontal, malar and superior maxillary bones. To this prominent bony margin is attached the tarso-orbital fascia, which separates the tissues outside the orbital cavity from those within it.

In the outer forward part of the orbit, just internal to the external angular process of the frontal bone, is the *lacrimal fossa,* a depression for the reception of the lacrimal gland. At the anterior extremity of the nasal wall is the *lacrimal groove* for the lacrimal sac. The anterior portion of the groove is formed in the strong nasal process of the superior maxillary bone, while the posterior portion is formed in the lacrimal bone, which is as thin as an eggshell. The lacrimal groove is continuous below with the lacrimal canal, which communicates with the inferior meatus of the nose near its anterior end.

The *optic foramen* at the apex of the orbit is about 5 mm. in diameter, and allows the passage of the optic nerve and the ophthalmic artery, which furnishes the blood supply for the structures in the orbit. The optic commissure and nerve lie in contact with the wall of the sphenoidal sinus, and the nerve is in close anatomical relationship with the posterior ethmoidal cells. This is of the utmost surgical importance in both nasal and ophthalmic surgery, as infection in these accessory nasal cavities may lead to inflammatory involvement of the optic nerve and consequent blindness. The optic nerve is attached to the eyeball a little to the nasal side of its posterior pole, approaching the eyeball in a curved manner and allowing, through its laxity, free movement of the eye. External to the optic foramen is the *sphenoidal fissure* through which pass the third, fourth, the ophthalmic division of the fifth, and sixth cranial nerves, sympathetic nerve and ophthalmic vein. The third, fourth, and sixth nerves are motor nerves for the supply of the muscles of the eyeball and elevator of the upper lid, while the ophthalmic division of the fifth supplies sensation for the ocular structures. The *sphenomaxillary fissure* is longer than the sphenoidal fissure but of less surgical importance. It is formed at the outer boundary of the posterior portion of the floor of the orbit. It allows the passage of the superior maxillary nerve which pierces the floor of the orbit to emerge below the orbital margin from the infra-orbital foramen.

The *eyeball* with its fascial covering (Tenon's capsule) rests in orbital fat in the anterior part of the orbit. It is almost a perfect sphere with a diameter of a little less than 1 in. (23 mm.). The movements of the eye are governed by 6 *muscles* called the superior rectus, inferior rectus, internal rectus, external rectus, superior oblique and inferior oblique. The 4 recti have their origin at the apex of the orbit around the optic nerve and diverge as they pass forward to their insertions in the sclera about 6 mm. from the margin of the cornea. The superior oblique also has its origin at the apex of the orbit, and passes forward along the superonasal angle of the orbit almost to the orbital margin, where it passes through a pulley of fibrous tissue, and changes its direction so as to pass downward, backward, and outward for its insertion to the eyeball behind the equator. The inferior oblique muscle rises from the floor of the orbit close to the orbital margin just external to the opening into the lacrimal canal. It passes backward, outward, and upward for its insertion to the eyeball a little behind the equator. The elevator of the upper lid (levator palpebræ superioris) rises at the apex of the orbit a little above and in front of the optic foramen. It spreads out as it passes forward near the roof of the orbit and is inserted by a broad tendon into the upper border and the anterior surface of the tarsal cartilage of the upper lid.

INCISION OF THE ORBIT

Exploratory Incision.—Incision of the orbit almost always calls for general anesthesia. Not uncommonly, the cause of the swelling of the orbital tissues, as manifested by exophthalmos, is a puzzling condition. The surgeon is justified in making as free an incision as may be necessary in an attempt to find the cause, which may be a pus collection, hemorrhage, cyst, accessory sinus disease, benign or malignant tumor.

Incision for Orbital Cellulitis or Abscess of the Orbit.—Usually infection of the orbit, resulting in abscess, is due to a rupture of the orbital wall and escape of pus from the frontal, ethmoidal, sphenoidal, or maxillary sinus. The most common ruptures are from the anterior ethmoidal cells and frontal sinus, through the thin bony partition which separates the frontal and ethmoidal cavities from the orbit. The periosteum may or may not be ruptured.

The position of the incision for abscess of the orbit must be governed by the probable location of the pus collection. It is sometimes impossible to make out the exact situation of the orbital abscess and sometimes the pus is not localized. The incision should be made close to the wall of the orbit so as to avoid injury of important structures. It would be better to avoid incising on the nasal side on account of the liability of injuring the superior and inferior oblique muscles, but, unfortunately, the pus collection is most liable to be near these muscles, and best drainage is procured by making the opening on the nasal side. Injury to the levator palpebræ superioris with consequent ptosis may follow an incision above the eyeball and this should be avoided if possible.

Careful probing usually reveals the cause of pus collection for which an incision has been made. It is most commonly ethmoiditis or frontal sinusitis. It is evident then that incision and drainage of the orbital abscess is usually only a temporary means of alleviating a dangerous condition, and a more radical procedure on the accessory sinuses or bone of the orbit must follow before healing will take place. Such an operation is usually within the realm of the nasal surgeon rather than the ophthalmic surgeon.

After incision of an orbital abscess the wound should be kept open with gauze or drainage tube, and a large wet gauze dressing should be kept on.

Incision for Tumors.—Rarely, small encapsulated tumors situated in the fore part of the orbit can be removed through a simple incision in the skin near the orbital margin. The opening should be large enough to enable the surgeon to work with freedom and not to injure unnecessarily either the tumor or orbital structures. Attempts to remove tumors in this way often result in failures and must be followed by a more radical procedure, such as exenteration of the orbit or Krönlein's operation. Before sewing the wound it is well to be sure that all bleeding has been stopped to avoid hematoma. The tarso-orbital fascia should be sutured with catgut before closing the skin wound.

Foreign Bodies in the Orbit.—Foreign bodies which penetrate into the orbital tissues are usually pieces of wood, stone, or metal, and unless the location is manifest the X-ray should be resorted to for the exact localization. It is often wiser to allow non-infected foreign bodies to remain in the orbital tissues than it is to attempt to remove them. Pieces of metal have been carried in the orbit for many years without any harm, and their removal is often hazardous to the eyeball.

The location and depth of the incision and manner of removal of a foreign substance in the orbit must be governed by the character, size, and position of the body. It is seldom that the electromagnet is of service in delivering foreign bodies from the orbit, whereas it is of utmost value in delivering them from the eyeball. If a foreign body has carried a virulent infection into the orbital tissues, removal should be performed as soon as possible and drainage maintained until the wound is closed.

KRÖNLEIN'S OPERATION (OSTEOPLASTIC RESECTION OF THE OUTER WALL OF THE ORBIT)

This operation was designed for the removal of orbital growths, particularly retrobulbar tumors, without sacrifice of the eyeball. The operation may be performed also for the removal of foreign bodies in the orbit. In this operation a large part of the orbital wall with its fleshy attachments is hinged back so as to expose the orbital tissues, and after removing the tumor it is sewed back into position. General anesthesia is always administered.

INSTRUMENTS.—Scalpel, tooth forceps, anatomical forceps, fine dissecting scissors, heavy blunt scissors, hemostats, periosteal elevator, chisel and mallet, fine saw, bone forceps, retractors, probe, needle-holder, gut and silk sutures.

OPERATION.—The first step is the incision of the soft parts (Fig. 112). This is curved with its convexity forward. It starts about 1 cm. above and behind the external angular process of the frontal bone and ends about the middle of the zygoma, curving forward to the orbital margin. This makes a cut about 7 cm. long. The upper portion of the incision extends into the temporal muscle, but not to the bone, while the middle and lower portions should extend to the bone.

Next the periosteum is incised along the outer margin of the orbit, and with an elevator is separated from the external wall within the orbit. When the sphenomaxillary fissure is reached a probe may be placed in the anterior end of the fissure and kept there as a guide.

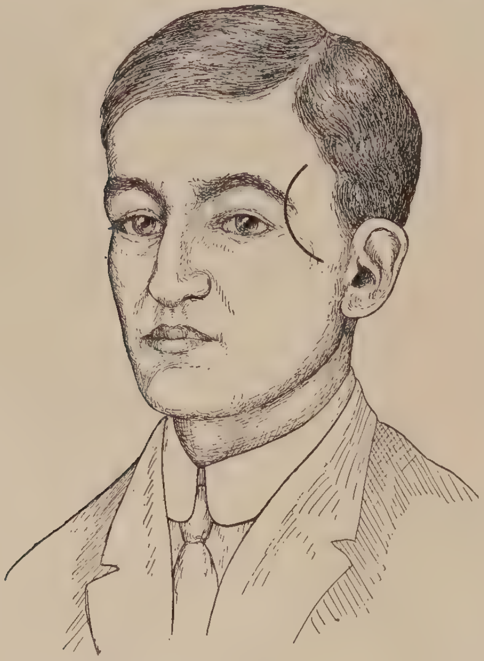


Fig. 112.—Skin Incision in Krönlein's Operation.

The next step is the cutting of the bone. This may be done either with chisel and mallet or with a fine saw. The first incision passes through the base of the external angular process of the frontal bone a little above the frontomalar suture and is carried downward and backward to the sphenomaxillary fissure at about its middle. The second incision starts about 3 cm. below the first, and is carried through the base of the orbital process of the malar bone to the anterior end of the sphenomaxillary fissure (Fig. 113). Then with a pair of strong blunt scissors the incision is extended along the tissue of the sphenoidal fissure to the posterior end of the first incision. These two incisions form a wedge with its apex at the sphenomaxillary fissure and its base at the orbital margin.

Now the wedge of bone with the soft parts is hinged back out of the way and held there with retractors. A horizontal incision is made with scissors through the periosteum, which has been elevated from the external orbital wall. This cut may be made along the upper or lower border of the external rectus muscle and the two flaps of the periosteum are held open with retractors.

If the tumor is to the temporal side of the orbit it may present at once; if not, the external rectus muscle will have to be held aside or cut. If it is divided, a gut suture should be introduced into each of the severed ends and these same sutures may be used for bringing the ends together later on. The growth is brought into view by holding the wound well open and throwing good illumination into the cavity. Care should be taken that all of the tumor, without unnecessary injury to the normal structures, is removed. If it is found that a malignant growth is diffused throughout the orbital tissue, exenteration of the entire contents of the cavity may have to follow.

The periosteum should be united by fine gut sutures, and, after replacing the wedge of bone, the incision in the skin is closed with silk sutures. Some operators choose to place a small drain near the lower end of the incision. Bichlorid vaselin 1:5,000 should be smeared along the palpebral fissure and a large gauze dressing and bandage applied. This is left on for 2 or 3 days and the skin sutures removed in 5 or 6 days. Following this operation there are transient exophthalmos and muscular paresis.

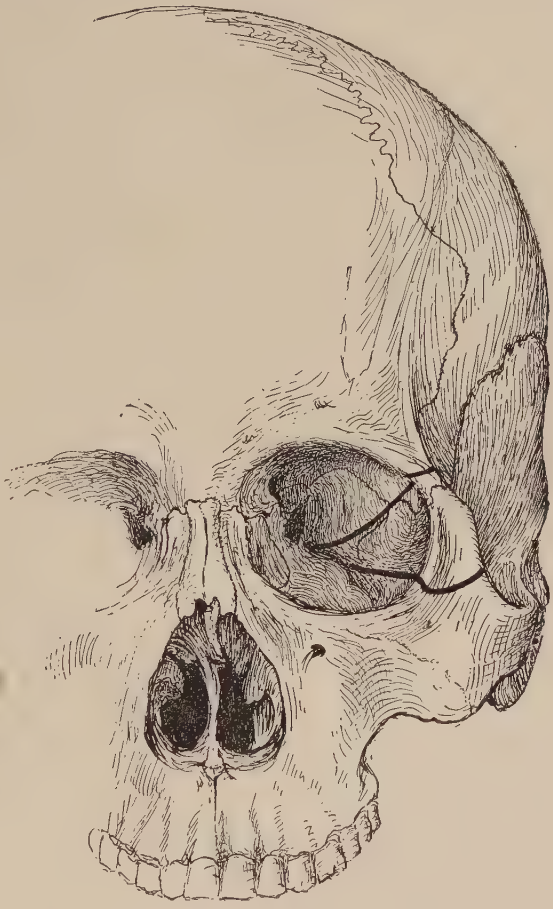


Fig. 113.—Bone Incision in Krönlein's Operation.

EXENTERATION OF THE ORBIT

The operation for the removal of the entire contents of the orbit is performed for malignant neoplasms which have invaded the contents of the orbit to such an extent that it is not safe to attempt to save the orbital structures. The tumor may be primarily of the orbit or may be one which has invaded the orbital tissues from the interior of the eyeball or its surfaces, or from one of the neighboring accessory sinuses.

INSTRUMENTS.—Scalpel, anatomical forceps, fine tooth forceps, blunt scissors, pointed scissors, periosteal elevator, retractors, hemostats, curet, needle-holder, and sutures.

OPERATION.—General anesthesia is always required. The position of the primary incision depends upon whether or not the eyelids are to be removed. As much of the skin of the lids should be preserved as is possible with safety. If the entire eyelids have to be removed the incision is made through the skin at the orbital margin. If the eyelids can be entirely preserved the incision is made through the conjunctival surface. An incision (canthotomy) should be made at the outer and inner canthi so that the eyelids can be turned back out of the way.

The incision is carried to the orbital margin and the periosteum is cut through all around the margin; and then, with an elevator, the periosteum is separated from the bony wall of the orbit. The detachment of the periosteum from the orbital wall is very easily performed except along the sphenomaxillary and sphenoidal fissures and at the apex of the orbit, where the scissors must be used. The periosteum clings a little also at the attachment of the superior oblique pulley and at the small foramina. In elevating the periosteum from the nasal side care must be taken not to injure the lacrimal bone and the os planum of the ethmoid.

After the periosteum has been freed from the bone, except around the optic foramen, gentle traction should be made on the mass and it should be cut free as near the optic foramen as possible. A brisk hemorrhage follows the cutting of the ophthalmic artery and firm pressure with gauze tampons should be applied. If it should fail to arrest the hemorrhage the actual cautery may be resorted to.

If there is malignant involvement of an accessory sinus, this should be thoroughly cleaned out at once. Such portions of the eyelid as remain are stripped of their conjunctiva and eyelashes and laid back on the orbital wall or they may be sutured together except for an opening for packing and drainage. If the malignant tissue has been entirely removed, healthy granulations will spring up in a few days to cover the orbital wall. If the operator chooses, he may hasten healing by laying Thiersch grafts on this granulation tissue. Considerable deformity follows exenteration of the orbit and a covering in the form of a patch is usually worn to hide the unsightly cavity.

CHAPTER III

OPERATIONS UPON THE EAR AND THE ADJACENT STRUCTURES

T. L. SAUNDERS

It is my intention to consider in the following article the commoner surgical diseases of the ear and their complications which occasionally fall to the lot of the general surgeon; and it is for his help and guidance, as well as for the specialist, that the following pages are intended.

For an intelligent appreciation of the various indications for the operations upon the ear, and its adjacent structures, a knowledge of the normal and pathological appearances of the drum membrane is absolutely necessary. The proper scope of the operative procedures can only be correctly estimated by a careful physical examination of the membrana tympani, auditory canal, and mastoid process, and in many instances supplemented by a functional examination of its auditory and static activity.

DIAGNOSIS OF AURAL INFLAMMATION

HISTORY AND GENERAL CONSIDERATION OF SYMPTOMS

History.—The history of a patient suffering from a possible surgical disease of the ear should always be taken. It not infrequently gives valuable aid toward making the diagnosis and enables the examiner to conduct his physical examination more intelligently and with greater expedition.

The following points should be elicited:

1. Chief complaint.
2. Onset and predisposing cause.
3. Duration of attack.
4. Previous attacks.
5. Pain: Location, character, duration, how increased, when at its worst, insomnia.
6. Aural discharge: Amount, character, odor, duration.
7. Chills: Present or absent.
8. Nausea, vertigo and dizziness. vomiting.
9. General health.

Thus, by inquiries about the duration and previous attacks we are able in a case of mastoiditis to infer whether it is an acute attack or an acute exacerbation of a chronic case, and frequently by well-directed questions regarding the discharge we can gain valuable information regarding its chronicity. These facts are important, for, as will be seen later, they have a direct bearing upon the operative procedures involved.

Pain.—Pain is a most important symptom. It is usually expected at the onset of an acute otitis, while pain reappearing or occurring later in the course of the disease usually means an involvement of the mastoid or adjacent structures.

Pain in aural disease is of two kinds: Pain in the ear itself, of a shooting or throbbing character; and a general headache, dull or severe, localized or general. The occurrence of severe headache in a case of mastoiditis usually indicates that the limits of the process are not confined to the middle ear and mastoid process. Postoperative headache, if severe and of any duration, and if unaccounted for by a local condition, such as a cellulitis of the wound or erysipelas, portends as a rule involvement of the cranial cavity. On the other hand, the elicitation of the absence of pain is not always of equal value, for serious intracranial conditions can occur without this symptom.

Chills.—Chills, if unexplained by the causal disease at the beginning, indicate as a rule an extremely vicious and rapid invasion of the mastoid process or the formation of a thrombus in the lateral sinus. Likewise, chills occurring after operation and accompanied by a marked rise of temperature usually indicate the onset of a complication such as pneumonia, erysipelas or a sinus thrombosis.

Nausea, Vomiting, etc.—Marked nausea and vomiting, vertigo or dizziness occurring at the onset or during the postoperative course, lead us to suspect the brain or labyrinth.

PHYSICAL EXAMINATION OF THE EAR

The patient is most conveniently examined in a sitting position, with the ear in question turned toward the examiner. Both ears should always be examined. The recumbent position of the patient adds considerably to the difficulties of the examiner, and is used only when the general condition of the patient contra-indicates the upright position. In the upright position, if a head mirror is used, the source of illumination should be on a level with and slightly behind the patient's ear, and so placed that the angle formed by the light, the head mirror of the examiner and the ear to be examined is one of 45 degrees.

For office or hospital work a special electric light (Coakley-McKenzie) or an Argand gas burner on an adjustable bracket is advisable. For examining patients in the recumbent position, and for occasional examinations in the home of the patient, an electric headlight with a pocket battery (Wappler Elec.) has been found most convenient by me. In the absence of this, other sources of illumination may be devised.

Instruments.—The instruments necessary for a routine examination of the membrana tympani are:

1. Set of ear specula, Gruber or Boucheron pattern.
2. Cotton applicator.
3. Metal ear syringe.
4. Small angular forceps.

The head mirror, if used, should be about 3 in. in diameter, with a fairly large hole in the center (3/8 in.) and fastened to a leather or wood-fiber adjustable head-band by a double ball and socket joint.

The aural syringe should be of metal, with a tight but smoothly running plunger.

Syringing.—All solutions, normal salt, boric acid or bichlorid 1:5,000, used in the ear, should be comfortably warm. The temperature in each case should be tested by first syringing the outer part of the auricle and following the wishes of the patient. The most comfortable temperature will usually be found to be about 104° F., and this temperature can conveniently be used in small children. If a thermometer is unavailable, the solution should be made so as to be just comfortably warm when syringed on the bare forearm of the examiner.

Syringing is a most efficient means of removing discharge and detritus from the canal, as a preliminary to careful inspection of the drum, and if performed in the following manner will be found far more comfortable than the time-honored method of wiping out the canal by a wisp of cotton on an applicator. In the majority of instances the drum picture, hitherto rendered indistinct and obscure by the discharge or detritus, will become clean-cut and typical.

It should be performed in the following manner: The patient's head should be slightly tilted so that the horizontal plane of the canal is directed outward and upward. The syringe is filled with the warm solution, and its tip held directly upward and all air expelled. It is then laid gently in the entrance of the canal and the canal slowly filled. When filled, more force can be used so that the return flow washes out the discharge into the basin held beneath the ear. This is repeated several times until the return flow is clear. The patient's ear is then tilted downward, and the fluid remaining in the canal allowed to run out. If any remains at the time of examination, it can be gently absorbed by a wisp of cotton upon an applicator. If the air is not expelled from the syringe, or if a stream of fluid is impinged forcibly against the drum head, the physician will cause considerable pain or discomfort. Gentleness should be the key-note in manipulations about the ear. The importance of carefully cleaning the ear in this manner cannot be overestimated, for if so done, many mistakes in diagnosis will be avoided. Its omission is an error seen only too frequently.

Introduction of the Speculum.—In using the speculum, the largest that fits comfortably into the patient's ear should be taken. Pain is caused by attempting to force a large speculum into a small auditory canal; and if the examiner uses too small a speculum, he will deprive himself of an adequate view of the drum head.

The speculum is inserted in the following manner: To straighten the canal the auricle is pulled upward and backward in adults, and downward and backward in infants, by the fingers of the left hand, and the speculum inserted snugly as far as it will go, with a gentle rotatory movement. The speculum is then grasped by the thumb and index finger of the left hand and the auricle maintained in the same position by the index and middle fingers, now leaving the right hand free for the use of instruments or other manipulations. This procedure should be easily and comfortably accomplished unless the canal is swollen and tender, due to a furuncle or a diffuse inflammation. In cases of furunculosis, it is often impossible to insert the smallest specula so as to gain a view of the drum without the aid of an anesthetic.

Examination of Membrana Tympani and Auditory Canal.—The surgeon should learn to recognize the following conditions:

1. Normal drum membrane.
2. An acutely inflamed drum membrane, requiring incision, i. e. redness and bulging.
3. Sagging of the posterior-superior quadrant of the canal wall adjacent to the drum.
4. A furuncle on the wall of the ear.
5. Exostoses on the canal wall.
6. Evidences of chronic suppuration, i. e. large perforations with thickened edges, polyps and granulation tissue, remnants of the ossicles.

Lack of space prevents me from entering into a lengthy description of the various appearances of the drum membrane. Indeed no adequate description can be written. The surgeon must familiarize himself with the appearances by repeated examinations. However, I desire to give a few of the salient points.

1. NORMAL DRUM MEMBRANE.—The points to be recognized are: (a) its pearly gray color; (b) its translucency; and (c) the normal landmarks seen on its surface. The most prominent landmark is seen at the upper and anterior part of the drum as a pearly white dot, the *short process* of the *malleus;* in acute inflammations this is the first landmark to disappear, and in a subsiding inflammation the first to reappear. Extending downward and backward to the center of the drum is a white line, the long process or handle of the *malleus.* About this center is an opacity called the *umbo,* while extending from the umbo, almost, but not quite to the periphery, is seen a light reflex, *"the cone of light."* Further extending from the periphery to the short

process are seen 2 folds, the anterior and posterior folds. Of these the posterior is the more prominent and is sometimes mistaken for the handle of the malleus. These folds divide the drum membrane into 2 portions, that above called *Shrapnell's membrane,* and the part below, the *membrana vibrans,* or the vibrating part of the membrane.

2. ACUTE INFLAMMATION OF THE DRUM MEMBRANE.—Instead of a pearly gray, the membrane assumes a pink or red color. This first begins as a reddish blush in Shrapnell's membrane, and extends downward, posterior to the handle of the malleus, and soon covers the entire drum membrane. In the severer cases, *bulging* soon follows. This bulging is not perfectly symmetrical like the outer surface of a hemisphere, but the upper and posterior part of the membrane is seen to stand outward (nearer the examiner) and over the anterior and inferior portion. In cases where the process is of long duration, the drum takes on a thickened soggy appearance, which, to the experienced observer, is quite characteristic.

3. SAGGING OF THE CANAL WALL.—This should always be looked for in a case of any duration, and in every case of suspected mastoiditis. If present, it is a valuable and enlightening symptom, denoting an extension of a purulent inflammation into the mastoid antrum and adjacent cells, and in the vast majority of instances forms a positive indication for a mastoid operation. It partly obscures the drum membrane, the lower and anterior part only being visible. In many cases the upper and posterior part of the wall seems to slope gradually downward and shade insensibly into a chink of drum membrane at the anterior and innermost part of the canal.

4. FURUNCLE OF THE AUDITORY CANAL.—Inspection of the outer canal wall usually precedes the actual examination of the drum membrane, either before or after the introduction of the speculum. The swelling of a furuncle may be seen, or its preliminary stage may be detected by the determination of a spot of localized tenderness along a canal wall. This is accomplished by the passage of a large blunt probe along the canal walls, using moderate pressure, introducing the probe and drawing it successively, from within outward, over the superior anterior inferior and posterior canal walls. This is a valuable diagnostic point, for a patient will wince and complain of pain when the site of the furuncle is reached.

5. EXOSTOSES.—Exostoses have the following characteristics: They are rounded or oval swellings on the canal wall, especially at its anterior and superior part, near the drum. When touched with a probe they give a stony resistant feeling, which distinguishes them from an inflammatory or cystic swelling.

6. CHRONIC SUPPURATION OF THE MIDDLE EAR.—It is not always easy to diagnosticate chronic suppuration from examination of the drum, but the presence of polyps or granulation tissue, large perforations with thickened edges, together with a fetid odorous discharge, makes us practically sure of the long duration of the process.

Examination of the Mastoid Process.—Upon inspection is noted the general shape of the mastoid process, any redness, swelling or obliteration of the postauricular fold. Pus beneath the mastoid periosteum gives a characteristic picture. There is a fullness of the postauricular tissues, the postauricular fold, which marks the junction of the auricle with the mastoid bone, is obliterated especially at its upper half, and the auricle itself is displaced downward and outward. This indicates either a furuncle of the canal that has burrowed backward, or a mastoiditis that has perforated the mastoid bone itself.

MASTOID TENDERNESS.—In acute middle ear and mastoid disease, the mastoid process should be examined carefully and systematically for the presence or absence of mastoid tenderness. The right hand is used for examining the left ear of the patient, and vice versa. With the fingers of the examiner resting lightly on the patient's neck, the following points are firmly pressed with the tip and ball of the thumb.

1. Over the mastoid antrum.
2. Over the posterior bony canal wall.
3. Over the mastoid tip.
4. Over the entrance of the mastoid emissary vein, which lies along the posterior border about 1¼ in. from the mastoid tip.

If necessary, firm pressure should be made over the bone and the comparison should always be made with that of the opposite side. It should be remembered that in certain nervous individuals tenderness may be elicited from a sound mastoid. In this procedure care must be taken not to involuntarily move the auditory canal, for in cases of furunculosis so doing may cause the patient to interpret the tenderness of the canal as mastoid tenderness.

Tenderness in front of the tragus and upon movement of the auditory canal is usually elicited in cases of furunculosis.

FUNCTIONAL EXAMINATION OF THE EAR

Acute suppurative cases of the ear and mastoid should be roughly tested each day with the voice and watch. An increasing deafness usually indicates that the disease is progressing; on the other hand, steady improvement in the hearing indicates usually that resolution has begun.

Before operating on any chronic suppurative condition of the middle ear or mastoid, the condition of absolute deafness should be determined and the reaction of the semicircular canals obtained. In no other way can we eliminate a latent disease of the labyrinth (see Labyrinthitis).

GENERAL AIDS TO DIAGNOSIS

1. **Smears of Aural Discharge.**—A knowledge of the infecting microorganism is often of extreme value in deciding for or against an operation

in the acute cases. Formerly cultures were taken, but these were found to be nearly always mixed infections. It has now been clinically found that equally valuable information may be obtained by examining smears of the aural discharge. The predominating organism in the smear of the aural discharge is usually found in the mastoid pus (obtained at operation) in pure culture. The streptococcus and the streptococcus mucosus capsulatus cases are the most severe.

The streptococcus mucosus may cause grave destruction of the temporal bone out of all proportion to the clinical symptoms, and I believe it a sound surgical principle to operate on all cases of streptococcus mucosus infection of the middle ear and mastoid which do not, within a week after the first paracentesis, show a steady improvement.

2. **Blood Counts.**—In uncomplicated cases of mastoiditis the blood count is usually normal and is not of much help in deciding for or against operation. However, in certain cases the absence of an abnormal count is of help in ruling out a complication (sinus thrombosis, meningitis, pneumonia, etc.). Bacon, however, believes that a rising polynuclear count in a case of mastoiditis usually indicates that the case is, or will become one which should be operated upon.

3. **Blood Cultures.**—Positive blood cultures are of great aid in the diagnosis of sinus thrombosis, provided other sources of positive cultures outside the ear can be excluded, and in cases where the diagnosis of sinus thrombosis has been established they form one of the indications for the resection of the jugular vein. Negative blood cultures have no diagnostic value. In the majority of instances, ear disease plus a positive culture means a sinus thrombosis *if* other sources of positive culture can be excluded with certainty.

4. **X-ray.**—X-rays of the mastoid have now been perfected so that in conjunction with the clinical symptoms they give valuable information as to the pathological process within the mastoid. The shape, location, and character of the cells in the mastoid may also be determined, and valuable information may be elicited before operation as to the location of the lateral sinus. Their greatest value is in differentiation between cases of furunculosis and mastoiditis which show swelling and edema behind the ear, and in which a view of the drum cannot be obtained. Pus in the mastoid is indicated by an abnormal cloudiness or shadow together with a blurring of the cell outlines. Unfortunately, to get good mastoid X-rays it requires an expert operator and one skilled in its special technic.

MYRINGOTOMY OR INCISION OF THE MEMBRANA TYMPANI

This operation is of immense importance in the cure of acute otitis media and acute mastoiditis.

Indications.—1. In acute otitis media, when the membrana tympani is red and bulging.

2. In acute otitis media, when the drum is red and the patient suffers severe pain.

3. In acute otitis media, when the mastoid symptoms are present.

4. In subacute catarrhal otitis media, when fluid (mucus) persists in the middle ear.

5. In cases of otitis media, where resolution is delayed by obstructed drainage.

6. In acute exacerbations of chronic otitis media, where pus is retained in the attic or atrium.

Anatomical Considerations.—In a drum needing incision the normal landmarks (see page 94) of the membrane are obscured, but their position in the upper and anterior portion must be remembered and avoided. It must also be remembered that the drum is placed, not at right angles, but obliquely to the long axis of the canal, and that the upper part of the membrane is nearer the operator than the lower part. The inner wall of the middle ear is about 2 mm. internal to the drum membrane, and this, at its posterior part, contains the foramen ovale and stapes above and the foramen rotundum below. These apertures are usually protected from injury by the overhanging ledge of the posterior canal wall. Through the upper part of the middle ear runs the chorda tympani nerve; its injury is occasional and trifling. It must likewise be remembered that Prussak's space is almost entirely shut off from the atrium or lower part of the middle ear, and when drainage of this area is necessary the incision must be carried above the posterior fold and well into the membrana flaccida. Occasionally the jugular bulb lies exposed in the floor of the middle ear and rarely, by a dehiscence in its canal, the facial nerve is separated from the posterior and inner part of the middle ear cavity by a fibrous membrane only. These anatomical anomalies are rare and need not be taken into serious consideration. **In general then the posterior and lower portions of the drum membrane are available for incision.**

Instruments.—The instruments necessary are:

1. Aural specula.
2. Sterile cotton swabs.
3. Small dull ring curet, Bacon model.
4. Aural syringe, small pus basin.
5. Paracentesis knife.
6. Sterile cotton.
7. Sterile boric acid solution.
8. Electric head light or head mirror.

The knife should have a narrow blade ½ in. long, and a shank and handle of about 6 in. The blade and handle may be in one straight line or the shank and knife may be set at an angle of 45° on the handle. Some otologists believe that with the angular knife they can better see the line of *the incision.*

Anesthetic.—Myringotomy is extremely painful, and unless there is some strong contra-indication this operation should always be performed under a general anesthetic. For adults nitrous oxid is preferable; for children, ether administered to the primary stage, or a small amount of chloroform—exceptions to this rule being infants under 6 months of age. If the patient is under an anesthetic, the operator can proceed with greater accuracy and deliberation. If the operation is attempted without an anesthetic, the operator must be content with an inaccurate and hurried stab at the drum membrane, and no matter how great the patient's fortitude and no matter how firmly he may be held, a flinching movement of the head is unavoidable.

As a poor substitute, and as a means of lessening the pain when the general anesthetic is not obtainable, a fresh 4 per cent. solution of cocain in equal parts of anilin oil and 95 per cent. alcohol may be used as a local anesthetic. A pledget of cotton is saturated with this solution and packed gently against the drum. This is allowed to remain for 10 minutes. Care must be taken, in cases in which there has been a previous incision or a large perforation, that the solution does not run down the eustachian tube into the throat and cause acute cocain poisoning.

It is beyond the province of this article to discuss the various merits of ether and chloroform; from the standpoint of the operator there is no choice. Frequently in children, especially in the neighborhood of New York City, acutely inflamed drums, requiring incision, are seen, which are simply part and parcel of a severe infection of the entire respiratory tract, i. e. pharynx, trachea, bronchi, and lungs. At the onset, signs in the lungs are indistinct, only to develop later.

On this account I have been in the habit of using chloroform instead of ether, unless the lungs can be ruled out with certainty. While perhaps, on general theoretical grounds, the routine administration of ether would be safer, I have never seen any ill effects from the use of chloroform in this connection, when administered slowly, with plenty of air and by a competent anesthetist. In either case only a small amount of anesthetic is necessary.

Preparation.—The *instruments,* with the exception of the knife, must be sterilized by boiling. The knives are sterilized by dipping in liquid phenol and then in alcohol.

It is impossible to render the *auditory canal* sterile. It may be efficiently cleansed by syringing it with a warm boric acid solution and drying it gently with sterile cotton swabs. Further efforts at sterilization are inefficient and unnecessary.

Line of Incision.—This should be a curvilinear incision, beginning below at the most dependent part of the drum, and hugging the posterior border, extending upward to the posterior fold, and if Shrapnell's membrane is involved, through the posterior fold well into Prússak's space. In cases of mastoiditis, where there is drooping of the posterosuperior canal wall, at the completion of the above incision, the blade of the knife should be turned upward and backward, and then drawn outward along the canal wall for the distance of 1/4 in., incising these tissues to the bone.

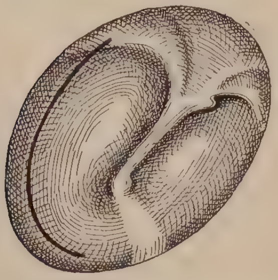


FIG. 1.—DRUM MEMBRANE SHOWING THE RELATION OF THE LANDMARKS TO THE USUAL INCISION.

If the operator is inexperienced and if the position of the landmarks is doubtful, the drum may be incised from the umbo downward to the floor of the canal. This incision is not ideal, but in the majority of cases furnishes adequate and useful drainage. The knife should be held in the hand like a pen, the blade upward. It should be inserted through the entire thickness of the drum membrane and not simply scratch its surface. Neither should it be inserted too far through the drum and allowed to injure the mucous membrane of the inner wall. The curvilinear incision forms a narrow flap that, when pushed outward by the discharge, gives a larger aperture than one formed by pushing apart the edges of a perfectly straight incision.

After the incision there is usually free bleeding, the blood is allowed to clot in the canal for 10 minutes and is then removed with the syringe. If this is not done, it tends to remain in the canal and defeat the end of the operation, i. e. free and immediate drainage. After the blood clot is removed, a plug of sterile cotton is loosely placed in the ear to be changed as frequently as it becomes saturated with the discharge, and the patient is placed on irrigations of a boric acid or a normal salt solution. The ear should be irrigated at first at 3-hour intervals and later less frequently as the discharge lessens.

Dangers of Myringotomy.—DISLOCATION OF THE STAPES, PERFORATION OF THE OVAL WINDOW WITH SUBSEQUENT INVOLVEMENT OF THE LABYRINTH.—The two factors causing this are: (a) the clumsy inexperienced operator; (b) incising the drum from above downward instead of from below upward, and carrying the knife too far inward at the start, engaging the stapes and tearing it out of the oval window. This danger is remote as the stapes is usually protected by the facial ridge.

PERFORATION OF THE JUGULAR BULB FACIAL NERVE OR INNER WALL OF THE MIDDLE EAR.—These dangers are extremely rare and can be caused only by extreme roughness or congenital malformations of the middle ear.

FRACTURE OF THE MANUBRIUM OF THE MALLEUS.—This accident may be caused by an inexperienced operator incising the center of the drum instead of its posterior border.

INCISION OF THE CANAL WALL.—The most frequent mistakes are: (1) Attempting to incise a red and swollen posterior canal wall instead of the drum. This mistake occurs when the membrana tympani seems to shade insensibly into the posterior canal wall, no line of demarcation apparently visible. This can usually be avoided as follows:

Observe carefully the juncture of the drum with the floor of the canal, and at the posterior part this line will be seen to curve upward, and an imaginary semicircular line projected upward from this point will give us the posterior border of the drum membrane. Kerrison (3) avoids this error by searching for the hammer handle, which is recognized by a linear depression in the bulging drum membrane. He then makes his incision 1½ mm. posterior to this.

2. INADEQUATE INCISION OF THE MEMBRANE.—Inadequate or partial incision of the drum membrane.

In some cases of otitis media, where the process has been a slow one and mild in character, the drum becomes considerably thickened. In these, unless the operator is careful, he is apt to incise the outer layer instead of the entire thickness of the drum. Considerable force is often required to push the knife through the thickened drum. When this has been successfully accomplished, the operator has the sense of cutting through a soft leathery substance into a free cavity beyond.

A short incision is often caused by a premature withdrawal of the knife.

Results: Behavior of Drum after Incision.—No apprehension need be experienced of leaving a permanent perforation. The major part of the incision heals in from 24 to 48 hours, leaving a small opening for drainage, which heals later. Severe pain is almost immediately relieved and immediate drainage is established. Re-incision is necessary in a certain number of cases.

FURUNCLE OF THE AUDITORY CANAL

(*Otitis Externa Circumscripta*)

Incision of a furuncle of the external auditory canal is indicated in the following cases:

1. In the stage of abscess as indicated by fluctuation, redness and pouting of the furuncle.
2. Before the stage of pus formation, where pain is extreme and not relieved by other measures.

A furuncle is an infection of a sebaceous gland in the fibrous canal wall. The bottom of the gland rests almost against the cartilage so that incision should be carried down to the cartilage to drain it effectively. The extreme pain is accounted for by the rich nerve supply and the unyielding nature of the surrounding tissues. I prefer to postpone incision until the stage of abscess formation, unless forced to do otherwise on account of the extreme pain, for nature by that time has erected her barriers of resistance, and subsequent infection of the surrounding tissue is less likely.

Instruments.—The instruments necessary for the incision of a furuncle are:

1. Those used for examination of the drum (see page 93).
2. Furuncle knife. This resembles a myringotomy knife, but the blade

and shaft are made much heavier to cut through the more resistant tissues. In case of emergency an ordinary myringotomy knife may be used.

Operative Preparation.—1. The ear is syringed with a warm boric acid solution and afterward dried and swabbed out with 95 per cent. alcohol.

2. An anesthetic is necessary (see Myringotomy). Local anesthetics are not efficient.

Technic.—With the patient under the anesthetic, as large a speculum as possible is introduced into the canal until the furuncle comes into view. The knife is then carefully introduced with the edge toward the furuncle until the point passes just beyond its inner border. The point is then pressed firmly into the furuncle and the knife withdrawn, incising the tissues of the furuncle down to the cartilage, opening well into the abscess cavity. The small curet is then inserted, the cavity gently curetted, and the "core," if any, of the abscess removed. A small wick of gauze is placed in the cavity and a wet dressing (aluminum acetate 10 per cent.) applied to the ear and allowed to remain for 24 hours. The dressing is then removed and the ear irrigated every 3 hours with a warm boric acid solution.

Recurrence.—There is a tendency for the tissues of the canal to become re-infected unless the irrigations are kept up for some time, and an occasional application of 95 per cent. alcohol made to the canal. It is needless to state that the general resistance of the patient should be increased by appropriate general treatment. I have found the use of a mixed staphylococcus vaccine (stock vaccine) especially useful in the prevention of re-infections.

SPECIAL OPERATIVE TECHNIC IN AURAL CASES

Operating Table.—The usual operating table is too low. For the operator of average height the table top should be about 36 in. from the floor. In addition to the table, several small sand bags should be available for the adjustment of the patient's head and shoulders.

Instrument Table.—This is usually a flat table about 36 in. by 20 in. On this the instruments should be conveniently arranged in a stated manner. When an instrument has been used it is immediately cleaned by the instrument nurse and laid in its accustomed place on the table. In this way the operator can tell at a glance the exact location of his instruments, and the consumption of valuable time in hunting for them is avoided.

Anesthetist's Shield.—The following device has been used for the past year with great satisfaction at the New York Eye and Ear Infirmary. It consists of a metal sheet 6½ in. by 9 in., swung from one end by a metal frame. This frame consists of a horizontal and a vertical portion. The horizontal portion is slipped under the pad on the operating table, at the patient's head, and the metal sheet swung over so that it rests on the patient's face, with its edge about an inch in front of the patient's ear. The sheet supports the towels and the hand of the assistant holding the retractor. It gives the anesthetist at all times a good view of the patient's face and lessens the chances of wound infection from this source.

Local Preparation.—1. Shave the head, including hair for an area of 2 in. around the ear. Irrigate the auditory canal with a warm bichlorid solution 1:5,000. Nurse's hands are now sterilized.

2. Scrub above area with green soap, sterile water, and then alcohol and ether. Flush with a bichlorid solution 1:1,000.

3. Tampon canal with sterile gauze, apply wet dressing bichlorid 1:2,000 and usual mastoid bandage.

When the patient has been placed on the table, the bandage is carefully removed by the anesthetist without touching the dressing, and the first assistant removes the dressing, surrounds the field with sterile towels and applies tincture of iodin to the operative field.

Ordinary Mastoid Dressing.

1. Canal packing, fine gauze, 1/4 in. wide by 6 in. long.
2. Mastoid packing, 2 pieces, 1/2 in. wide by 18 in. long.
3. Crescentic piece of gauze to be placed over mastoid wound.
4. Fluff gauze, 1 piece, 36 in. by 18 in.
5. Cotton wadding, 4 in. square by 1 in. thick.
6. Bandage, 10 yds. long by 2 in. wide.

Sinus Thrombosis (Neck) Dressing.

1. Three flat gauze pads, 4 in. by 8 in.
2. Gauze roller, 4 in. by 5 yds., containing 6 layers of gauze.
3. Cotton, 8 in. by 14 in., 1 in. thick.
4. Two bandages, 15 yds. by 2 in.

Mastoid Sponges.—These are convenient for sponging in the interior of the mastoid wound. They are easily formed by cutting gauze 9 in. square. Each square is then grasped in the center and pulled through the fingers, forming a narrow piece of irregularly folded gauze. The pieces are wrapped in packages and sterilized ready for use.

Solutions.—The solutions necessary on the instrument table are:

1. Boric acid solution (saturated) in a flat metal dish for cleaning instruments.
2. Warm normal salt solution.
3. Adrenalin, 1:1,000 (radical operations).

Preparation of Operator.—The ordinary operator's and assistant's rubber gloves, operating gowns, and face masks are suitable.

Instruments.—FOR SIMPLE MASTOID.

1. Paracentesis knife.
2. Aural specula.
3. Aural applicator and cotton.
4. Syringe (rubber or metal) and pus basin.

5. Scalpels (2) kept in alcohol.
6. Artery clamps (12-18).
7. Retractors, 2 sharp small 1 in. or self-retaining (Jansen) (Allport).
8. Periosteal elevator, Langenbeck's.
9. Probes, large and small, grooved director.
10. Mallet (wood or metal).
11. Chisels, Whiting pattern, 3 sizes.
12. Gouges, Whiting pattern, 3 sizes, and 1 small gouge for labyrinth.
13. Rongeur forceps (4).
    - Bayne's pattern.
    - Brandegee's pattern.
    - Mathieu's pattern.
    - Bacon's pattern.
14. Curets (12).
    - 6 Sprats or Volkmann, sizes 0 to 5.
    - 6 Richards, sizes 0 to 5.
15. Forceps.
    - 2 plain.
    - 2 mouse-toothed.
16. Scissors.
    - 1 straight.
    - 1 curved on flat.
17. Needles, No. 6 Hagedorn and needle-holder (universal), or Michel clamps and instruments.

MISCELLANEOUS.

6 safety pins for towels.
Plain and iodoform gauze (5 per cent.).
Silkworm-gut.
No. 2 plain gut ligatures.
Bone wax.
Extra sterile towels.

FOR RADICAL MASTOID.—In addition to above:

1. Flap knives $\begin{cases}\text{1 sharp.}\\ \text{1 probe pointed.}\end{cases}$
2. Whiting retractor or Stacke retractor.
3. Yankauer's eustachian curets (3).

FOR SKIN GRAFTING.

1. Pipet.
2. Small cotton pledgets rolled in aristol.
3. Two strips narrow packing, plain.

On an extra table:

1. Skin grafting razor.
2. 1 pair graft scissors.
3. 4 glass slides, 2 in. by 4 in.
4. 2 spatulas.
    2 teasers.
    2 packers.
5. 1 bowl of warm normal salt solution.
6. 6 towels.
    Adhesive plaster.
    Silver foil.
7. Leg dressing.

FOR LIGATION OF JUGULAR VEIN.—In addition to mastoid instruments.

1. Aneurysm needle
    - No. 2 plain catgut, several tubes.
    - No. 1 iodized catgut, several tubes.
2. Wide iodoform packing.
3. Long sandbag.
4. Cigarette drain.
5. 6 extra hemostats.

FOR BRAIN CASES.

1. Mastoid instruments.
2. 6 extra hemostats.
3. Brain knife.
4. Whiting's encephaloscope.
5. Brain retractors (2).
6. Cigarette drains.

FOR LUMBAR PUNCTURE.

1. Luer syringe.
2. Long needles with sharp stilet, 1 mm. inside bore.
3. Collodion.
    Cotton.
4. Green soap.
    Sterile water.
    Iodin.
    Alcohol.

Preparation for Skin Grafts.

1. Shave area (thigh).
2. Scrub thoroughly with green soap and water.
3. Flush with sterile water.
4. Flush with alcohol.
5. Flush with bichlorid 1:2,000.

6. Flush with saline.
7. Apply sterile dressing.

USE OF INSTRUMENTS

Mastoid Curet.—Mastoid curets are of two types, the spoon-shaped curet, of which the Volkmann curet is typical, and the bowl-shaped curet, of which the Whiting and Richards curets are examples.

To do satisfactory bone work curets should be *sharp.* They must be resharpened as frequently as is necessary to keep the edges in keen condition. Care must be taken that they are sharpened by grinding the inner surface of the spoon or bowl, and not simply by grinding away their external periphery.

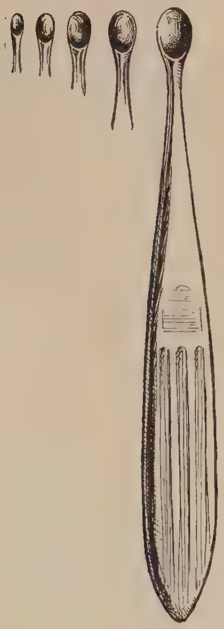


FIG. 2.—SPRATT'S CURET.

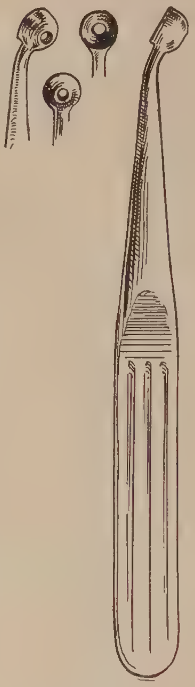


FIG. 3.—RICHARDS' CURET.

To work with a dull curet is tedious to the operator and dangerous to the patient. This may seem paradoxical, but the force required to make a dull curet do its work is a menace to the dura or sinus, should the instrument slip or accidentally encounter one of these structures out of its normal position. It is a sound operative axiom in doing mastoid work to use as large an instrument as can efficiently work in the operative cavity.

To American otologists must be given the credit for the development of the technic with the curet and the rongeur forceps.

The curet should not be used to pry away large pieces of bone in a haphazard manner, but has certain definite uses which the writer will endeavor to describe. They are as follows:

1. AS A PLANING INSTRUMENT.—This is useful to break down masses of cell partitions where the bone is fairly soft. Examples of this are seen in the completion of the initial groove and the removal of the cellular tissue from the antrum backward between the knee of the sinus and the dura. The work is done with the extremity of the instrument. The curet is held with the bowl toward the operator, and the hand of the operator well up toward the top of the handle. The curet is held in the fingers, and the thumb is either braced against the top of the handle or else is aiding the fingers in their grasp.

The motion is a *hoeing motion,* toward the operator, with tight pressure on the bone. This is rapidly and frequently repeated. It is accomplished chiefly by the wrist, but partly by a movement of the fingers.

2. AS A ROTARY CUTTING INSTRUMENT.—It is thus used to remove small, projecting pieces of bone, or is efficient in removing thin layers of bone overlying the vital structures. While not as rapid as the first method, this is safer. The curet is grasped chiefly with the index finger and thumb, the tips of the other fingers holding the instrument against the thenar eminence.

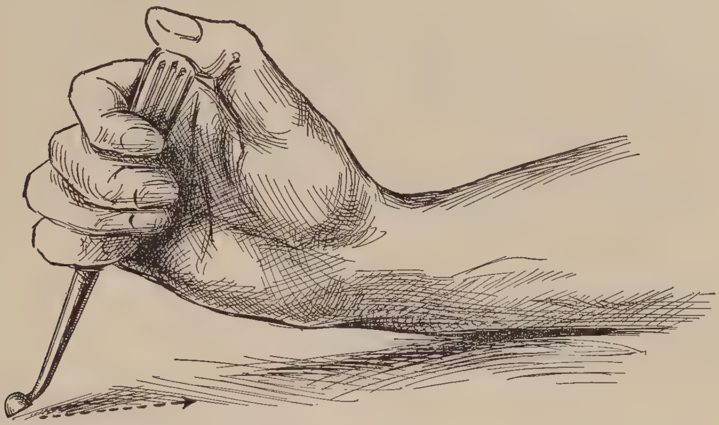


FIG. 4.—THE CURET AS A PLANING INSTRUMENT—THE BEGINNING OF THE STROKE. Note position of fingers and wrist.

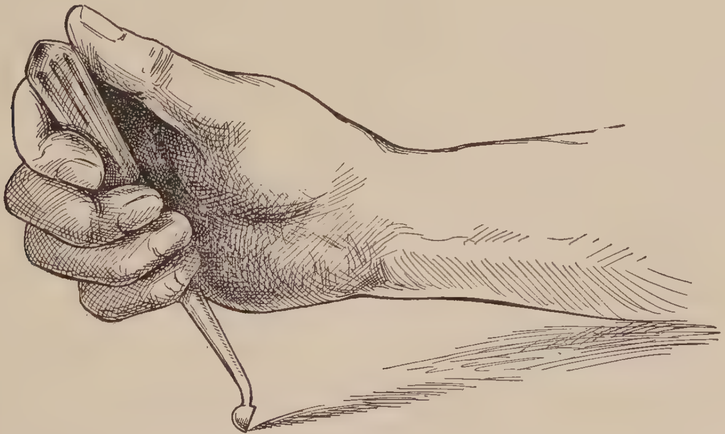


FIG. 5.—THE CURET AS A PLANING INSTRUMENT—THE END OF THE STROKE. Note position of fingers and wrist.

The curet is held at its desired location by the thumb and index finger of the other hand, and the bone scraped away by a rapid rotary motion of the wrist. Here the side and not the extremity of the curet does the work. In this manner the curet may *also* be used as a boring instrument, but this should be done sparingly and only by experienced operators, as there is danger in penetrating the underlying structures. In this rotatory movement, properly executed, the direction of the force applied to the instrument is parallel to the vital structures beneath the bone, and if the instrument slips, these are in less danger of being injured than if the force be applied directly against them.

3. FOR REMOVING PARTICLES OF BONE.—The curet may also be properly used for prying small thin pieces of bone away from the dura or sinus. Small pieces only are taken away at a time, and only enough removed in this manner to enable the operator to easily use the *rongeur forceps.*

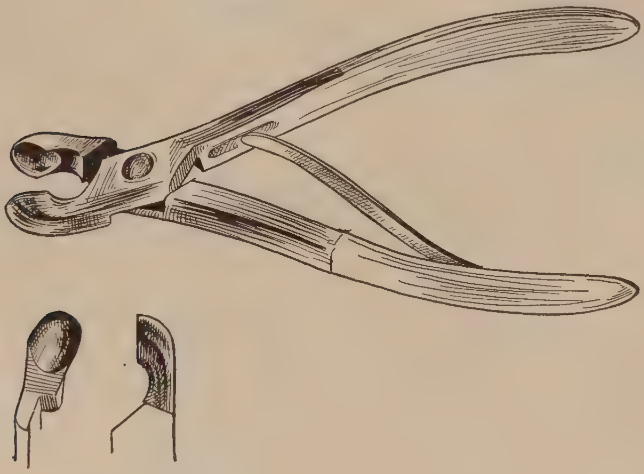


FIG. 6.—MATHIEU'S RONGEUR FORCEPS.

TYPES.—The Volkmann curet is useful both in the simple and radical operations. The curets of the Richards type find their special field in the radical operation. The Richards curet is made with a heel which can be effectively used as a fulcrum. When used as a planing instrument, the face of the curet should be kept as parallel to the bone as is possible, and the bone rapidly removed in thin shavings. The intelligent use of this instrument eliminates to a marked degree the necessity for a chisel in the radical operation.

By using the bone or fingers as a fulcrum and by a dipping and upward movement, the operator can plane away the bone from the interior of the cavity, working from within outward. This type of curettage is especially useful in lowering the facial ridge, the outer wall of the hypotympanum, and in removing the outer anterior wall of the attic.

Rongeur Forceps.—These instruments are the *time savers* in a mastoid operation. They have one main function, to bite away projecting or overhanging portions of bone. The fragment to be removed should be grasped firmly by the blades of the instrument, and as they are closed the rongeur should be prevented from slipping by the thumb and finger of the other hand. The fragment should be cut through cleanly, and there should be no wrenching or twisting motion, as this is liable to extend a line of fracture outside the fragment to be removed. Occasionally the rongeur is used as a curet, i. e. one blade engaged firmly and the other drawn toward it with a scraping motion. To save time the operator should use a rongeur whenever he can safely do so. The danger in the injudicious use of this instrument is the pinching or tearing of the dura, sinus or nerve.

Chisels and Gouges.—These are of various types and sizes. Personally I have found the Whiting pattern the most satisfactory. The jarring of the head by the repeated impact of the mallet against the chisel is a considerable factor in operative shock and in the dissemination of septic foci to various parts of the body. To obviate this the chisels and gouges should always be sharp, and should be used only when the bone cannot be readily removed by any other instrument. When used with discretion, they form a most valuable adjunct to the curet and rongeur forceps. When operating on an eburnated or sclerotic bone, they are indispensable.

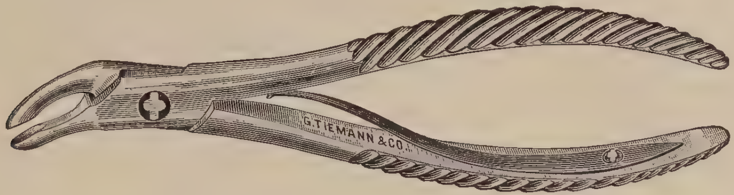


Fig. 7.—Bacon's Rongeur Forceps.

It has been an observation of mine that the postoperative pain and discomfort bear quite a direct relation to the degree to which a chisel or gouge has been used. In employing them, the bone should be removed in thin layers by light and oft-repeated taps of the mallet, and as a rule the chisel or gouge should be held as nearly parallel as possible to the vital structure underlying the bone. Personally I prefer an instrument with a fairly large handle, i. e. of the Whiting type. Other operators favor chisels and gouges having no handles (Schwartze). It is convenient to have 4 or 5 sizes of each, although I, for the past 4 years, have used but 2 sizes, large and small.

If the operator wishes the chisel to engage the bone rather deeply, he should turn the flat side toward the bone. Then at each tap the chisel will penetrate a little more deeply into the bone.

If he wishes to take off a very thin shaving, and is fearful of penetrating the deeper structures, he should chisel with the beveled edge turned toward the bone. The chisel then has a tendency to cut the bone parallel to its surface instead of penetrating more deeply.

Other special instruments will be mentioned in describing the operative procedures requiring their use.

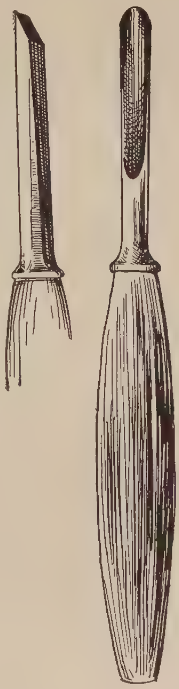


Fig. 8.—Whiting's Mastoid Chisel and Gouge.

In conclusion, it is hardly necessary to call attention to the danger of injuring the sinus, dura or facial nerve by the slipping of a chisel or gouge, and to its remedy,

i. e. grasping the instrument firmly in the hand and using the mallet with gentle and *frequent taps*. The operator should train himself to look not at the mallet, but at the point of the instrument.

REMOVAL OF FOREIGN BODIES IN THE EAR

Indications.—All foreign bodies that cannot be removed through the auditory canal without injury to the drum membrane, or extreme laceration of the auditory canal, require operative treatment. These are the hard solid bodies (beads, buttons, etc.) which almost completely fill the canal and which have been pushed in beyond the isthmus. Operative treatment is often made necessary by the inexperienced efforts of the previous attendant.

Operation.—PREPARATION OF PATIENT.—See Acute Mastoiditis.

INSTRUMENTS.—The instruments necessary are those employed for mastoid operation, and in addition:

(1) Foreign body hook.

(2) A pair of strong angular forceps.

TECHNIC.—A. The regular incision for the mastoid operation is made (omitting the horizontal incision), and the anterior periosteal flap elevated as far forward as the posterior canal wall.

B. The posterior and upper part of the membranous canal is carefully separated from the bone with a small curet or periosteal elevator.

C. The canal is now held forward with a narrow retractor and removal of the foreign body is attempted with forceps or curet.

D. If the above method of removal is unsuccessful, enough of the posterosuperior canal wall is cut away to gain free access to the foreign body. In case the body has been pushed within the tympanum and cannot be extracted by this last procedure, the tympanic cavity must be opened after the manner of a radical operation.

E. When the foreign body has been removed, the membranous canal is replaced and the posterior wound sutured, the canal snugly packed with sterile gauze, and the usual mastoid dressing is applied. The canal packing is removed in three or four days, and the posterior dressing can usually be dispensed with in a week to ten days, provided primary union has taken place. If the posterior dressing is taken off too early, before union has become firm, sagging of the ear is apt to occur.

WOUNDS OF THE EAR

For *lacerated wounds of the auricle and auditory canal*, the ear should undergo the usual operative preparation. (See Mastoid Operation.) Under a general anesthetic, if necessary, and with aseptic precautions, the edges of the wound must be approximated with interrupted silk sutures. These sutures should not include the perichondrium. If the fibrous canal has been torn from its bony attachment, it should be replaced and snugly packed with sterile gauze. A 10 per cent. aluminum acetate wet dressing is applied, a flat compress being placed behind the ear, another over the ear, and over this the usual mastoid dressing.

Bullet wounds of the ear are treated in the same manner.

For the removal of bullets, splinters, etc., see Foreign Bodies. Their immediate removal is indicated.

THE SIMPLE MASTOID OPERATION

(*Simple Mastoidectomy, Complete Mastoid Operation*)

The object of this operation is twofold, first to eradicate a suppurative focus in the antrum and mastoid cells, and second to cure the acute otitis by increased drainage of the middle ear. This is accomplished by removing the mastoid cortex, widely opening the antrum and by a thorough exenteration of the diseased mastoid cells, forming one large cavity which, at its upper and anterior part, communicates with the middle ear by the *aditus*.

All cases of *acute mastoiditis,* secondary to acute otitis media, may clinically be divided into two classes:

1. Those that recover under palliative treatment, i. e. myringotomy, irrigations, rest in bed, catharsis, etc.
2. Those that require operation.

In private practice, about 70 per cent. of the cases of acute mastoiditis are cured by the above measures without mastoid operation. The remaining 30 per cent. require operative treatment. In hospital and dispensary practice the percentage of cases requiring operation is much higher, owing to unhygienic surroundings and lowered resistance.

Indications.—In the majority of cases we can lay down no hard and fast rules for operative interference, but in determining the *operative cases* of *mastoiditis* we must take into consideration the following factors:

1. Duration of the process.
2. Condition and appearance of the drum membrane and canal wall.
3. Character and amount of discharge.
4. Mastoid tenderness and edema.
5. Pain.
6. Temperature.
7. Inciting micro-organism.
8. General constitutional symptoms.
9. Symptoms of intracranial complications.

1. DURATION.—The longer a mastoiditis has existed (without steady improvement) the poorer the prognosis as regards cure without an operation. It must be re-

membered also that the restoration of hearing is more rapid and more complete in those cases operated on soon after onset than in those operated on later in the disease, as will be seen further on. The duration and persistence of *the local symptoms,* such as pain, tenderness, discharge, are important operative indications.

2. APPEARANCE OF THE DRUM MEMBRANE AND CANAL WALL.—The drum membrane, in cases of acute mastoiditis of considerable duration, is apt to have a thickened and soggy appearance. A thick and soggy drum membrane, that shows no tendency toward resolution, especially when accompanied by a profuse discharge, is a fairly characteristic symptom of a marked suppurative condition of the mastoid process, and usually calls for operation.

Drooping or *sagging* of the posterosuperior canal wall adjacent to the drum, when present, is pathognomonic of suppuration in the mastoid antrum and adjacent cells, and is a positive indication for operation. Care must be taken *not to confuse* true sagging, which is due to an extension of the inflammation to the periosteum of this region, with the swelling of a furuncle, or with a diffuse swelling of the canal wall, sometimes seen in cases in which the irrigations have been too hot or too frequent. It usually develops 2 or 3 weeks after onset; in exceptional cases, earlier. Its absence is of no negative value, for many cases of operative mastoiditis have no drooping of the canal wall.

3. AURAL DISCHARGE.—Much can be learned by observing the amount and character of the aural discharge.

1. AMOUNT.—Immediately after incision we expect and desire a profuse discharge. This should gradually grow less, stopping usually in from 10 days to 2 weeks. If, on the contrary, it grows more and more profuse, it indicates a gradual involvement of the mastoid cells. A very profuse discharge of 3 or more weeks' duration usually indicates a mastoiditis demanding operation. This profuse discharge is invariably accompanied by other signs of mastoiditis, but often the experienced observer can make the diagnosis on this symptom alone.

Diminution in the amount of the discharge, accompanied by a lessening in the local and constitutional symptoms, indicates that resolution is taking place.

On the contrary, diminution in the discharge accompanied by an increase in the local and constitutional symptoms, denotes inadequate drainage either of the middle ear or mastoid process. If no change for the better follows immediate myringotomy, the mastoid process is at fault and operation is indicated.

2. CHARACTER.—Thick creamy pus in the auditory canal usually denotes mastoiditis. If this is of a dirty greenish color, operation is usually inevitable. The absence of pus of this character does not rule out mastoiditis.

The pneumococcus and the streptococcus cases are frequently characterized by a profuse bloody serous discharge. A fetid odor from the discharge in an acute case indicates an extremely virulent process with bone necrosis.

4. PAIN.—The persistence of deep-seated pain in the mastoid process or

cranium itself, after a myringotomy, is an indication for operation. In cases of mastoiditis that recover without operation, pain ceases soon after the myringotomy has been performed.

Attacks of deep-seated pain occurring during the course of a mastoiditis of considerable duration are of bad prognostic significance. These cases rarely recover without operation.

5. MASTOID TENDERNESS.—Many cases of acute otitis show more or less tenderness over the antrum, this usually clearing up after myringotomy. The significance of mastoid tenderness is its *persistence* after myringotomy, or its onset during the course of an acute otitis. Increasing mastoid tenderness indicates an increasing involvement of the bone.

The mastoid tenderness at onset, if due to simple congestion of the bone, steadily diminishes after myringotomy.

Post tip tenderness or tenderness over the mastoid emissary vein occasionally clears up if present at onset, but the presence of tenderness at these points during the course of the disease usually denotes a serious and widespread involvement of the mastoid process. On the other hand, let it be borne firmly in mind that the absence of mastoid tenderness does not rule out mastoid involvement.

Edema, redness, and swelling of the mastoid process (furunculosis ruled out) are posterior indications for an immediate mastoid operation.

6. TEMPERATURE.—High temperature at onset not accompanied by other symptoms is not an indication for operation. On the other hand, high temperature persisting, especially after myringotomy, for any considerable time, is usually an operative indication. However, we must be extremely careful to rule out causes of use of temperature other than in the mastoid bone. In this connection mention must also be made of persistent though slight elevations of temperature in cases showing few, if any, other symptoms. Any case of persistent aural discharge of considerable duration (4 to 6 weeks) that runs a temperature, however slight (99° to 100°), must be regarded with suspicion. If examined carefully, the majority of these cases show other signs of mastoid involvement, and usually come to operation. In a case of mastoiditis that is recovering under palliative measures, the temperature must drop to normal and stay there.

7. NATURE OF INFECTION.—In the majority of cases operation is decided upon irrespective of the type of infecting micro-organisms. In a certain number of borderline cases the knowledge of the kind of germ causing the suppuration is of the greatest aid.

I agree with Dr. Geo. S. Dixon that all cases of streptococcus capsulatus infection that do not show steady and rapid improvement at the end of 2 weeks, should be operated upon. In other words, we would operate upon a streptococcus case where, in a pneumococcus or staphylococcus infection, we might wait for further development of symptoms. The same is true, though to a lesser degree, of the streptococcus pyogenes infections.

8. GENERAL CONSTITUTIONAL SYMPTOMS.—Under this heading I place pallor, anorexia, furred tremulous tongue and insomnia. These symptoms are present in every well-marked case of mastoiditis of considerable duration. In cases where the local symptoms are not marked or are masked, a persistence of the above symptoms after myringotomy, irrigations, rest in bed, etc., constitutes a sound basis for operative interference.

In brief, then, every case of acute mastoiditis under incision, aural irrigations and rest in bed, should show a steady diminution in the local and general symptoms until complete resolution is reached. If, however, during its course, the local and general symptoms show a tendency to increase or to become stationary, operation should be considered; and if symptoms of beginning intracranial complication are present or develop at any time, immediate operation is indicated.

9. COMPLICATIONS.—Symptoms denoting irritation of the labyrinth, i. e. nystagmus, vertigo, nausea, and vomiting, occurring during an acute mastoiditis, demand immediate operation.

Chills and extremely high temperature, if general causes can be excluded, usually denote involvement of the dura or lateral sinus and form positive operative indications.

ANATOMICAL POINTS TO BE NOTED

In a simple mastoid operation the following anatomical points must be noted:

1. Surface markings:
    - (a) Posterior canal wall.
    - (b) Spine of Henle, suprameatal spine.
    - (c) Posterior root of zygoma.
    - (d) General contour.
2. Internal anatomy:
    - (a) Position of the mastoid antrum.
    - (b) Aditus.
    - (c) Vertical portion facial nerve.
    - (d) Horizontal semicircular canal.
    - (e) Incus.
    - (f) Dura.
    - (g) Sinus.
    - (h) General character of the mastoid cells.

Surface Markings.—After exposing the mastoid cortex the *posterior canal wall* is the first landmark to be noted. This marks the anterior limit of the reflection of the periosteum. This also forms the anterior boundary of the so-called *Macewen's triangle.* At the upper part of the posterior canal wall is seen a more or less well-marked spine, the *suprameatal spine* or spine of Henle.

Just above the suprameatal spine and extending upward and backward in a curved direction, is seen a well-marked ridge of bone, the *posterior root of the zygoma.* This forms the upper boundary of *Macewen's triangle,* and also, in the majority of skulls, the surface guide to the middle fossa. In a certain number of cases the dura is at a lower level, i. e. a horizontal line projected backward from the suprameatal spine.

Macewen's triangle is an imaginary triangle formed by the posterior root of the zygoma above, and by the posterior canal wall below and anteriorly. Its posterior boundary is formed by an imaginary line dropped vertically downward from the posterior root of the zygoma to the posterior canal wall. It is of importance as a guide to the antrum. If this triangle be projected inward, in a direction slightly forward and upward, at a variable depth of 1/4 to 1 3/4 inches, it will be found to include the *mastoid antrum.*

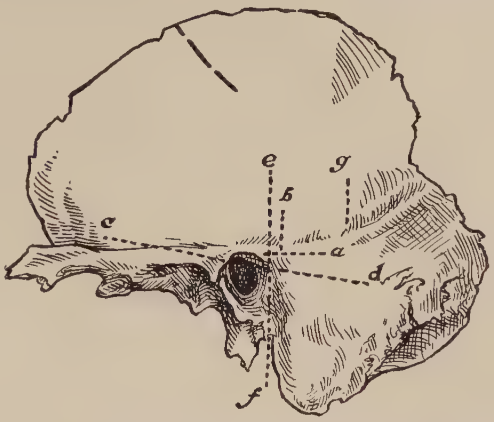


FIG. 9.—TEMPORAL BONE SHOWING SURFACE MARKINGS. Line *c d* drawn through suprameatal spine. Line *e f* posterior boundary of suprameatal triangle. Line *a*, horizontal line projected backward from the upper level of the bony canal wall; this sometimes marks the low level of the dura instead of the posterior root of the zygoma *g*.

The *general shape and contour of the bone* should be noted. It gives a clew to the position of the sinus. The sinus generally lies under the part of greatest convexity of the mastoid cortex (convexity from before backward) and in the narrow mastoids the sinus is apt to lie farther forward than in the mastoids having a large flat surface. A more accurate means of determining the position of the sinus before operation is by means of the X-ray (see page 97).

The Mastoid Antrum.—This is an irregularly shaped cavity of varying size, but usually having a diameter of about 1/4 to 3/8 in. It is situated at the upper and anterior part of the mastoid process, lying behind and slightly above the attic of the middle ear, with which it communicates by the *aditus.* All the mastoid cells communicate with the antrum, and it is here that infective material from the middle ear collects and is thence disseminated to all parts of the mastoid bone.

The dura is separated from the antrum by a thin plate of bone, the *tegmen antri.*

The Aditus.—This is sometimes described as a narrow passage-way, but is in reality simply the doorway between the antrum and attic of the middle ear. It is roughly triangular in shape with the apex upward. Its diameter is much less than that of the antrum.

Beneath its floor lies the facial nerve as it turns from its horizontal into its vertical portion. From its posterior part is seen the whitish prominence of the horizontal (external) semicircular canal. Just anterior to the canal and projecting backward from the middle ear is the processus longus of the incus. This process is liable to be injured, or the incus dislocated, by injudicious curetting of the anterior part of the antrum.

Horizontal Semicircular Canal.—This is recognized by a whitish oval mass usually standing out in sharp contrast from the reddish surrounding bone. Its position is given above. It forms an important landmark and guard for the facial nerve. On account of the extreme hardness of its bone, it is not liable to be accidentally injured by the careful operator.

Facial Nerve.—The vertical portion is chiefly concerned in the simple mastoid operation. It will be considered in its entirety under the radical mastoid. The surface marking of the facial nerve is represented by a line dropped from the spine of Henle vertically downward. Within the bone it lies internal to an anteroposteriovertical plane passed tangent to the *prominence* of the external semicircular canal. Thus it may be seen that a considerable portion of the posterior canal wall *may* be lowered without endangering its integrity. In the simple mastoid operation it is in danger of being injured on the following points:

1. On the floor of the aditus.
2. At the posterior part of the vertical portion, in curetting the deep anterior mastoid cells.
3. At its exit at the stylomastoid foramen, in removing the mastoid tip.

Anomalies in the *course* of the facial nerve have been noted, but they are rare. The position of the facial nerve is usually the most fixed of any of the structures *in the mastoid bone.*

Dura.—This is separated from the mastoid cells by a thin but very hard plate of bone, the dural plate. Over the antrum this is much thinner than the rest, and is called the *tegmen antri.* This plate joins the mastoid bone *usually* at the level of the posterior root of the zygoma. In exceptional cases it may be as low as a horizontal line passed backward from the spine of Henle. In this somewhat wedge-shaped area formed by the root above and the horizontal line below, the cortex of the bone and the underlying cells must be removed cautiously until the glistening hard surface of the plate itself is seen.

Sigmoid Sinus.—This is a direct continuation of the lateral sinus, and forms one of the most important surgical landmarks in the temporal bone. It shows as an oval curved eminence at the posterior part of the mastoid process. It is most important to note the extreme variability as regards its position. It may lie anywhere within the mastoid process. It usually occupies the posterior and inner part of the mastoid process, but frequently a more anterior position. In extreme cases it has been found to encroach on Macewen's triangle and overlie the antrum. A far forward sinus, so called, is one whose anterior border is 1/4 in. posterior to the canal wall at a level with the antrum, and about 1/8 in. posterior below this level. The average position of the sinus is about 1/2 to 3/4 in. posterior to the canal wall at a level with the antrum and slightly less below. Its position may be roughly estimated by observing the surface contour and shape of the bone. The sinus generally lies under the point of the greatest convexity in the mastoid bone. In mastoids that are narrow and very convex, the sinus is apt to be far forward. Lately a more exact means has been developed by the use of the X-ray (see page 97). In operating it is a safe rule to proceed with extreme caution until the hard shell-like bone covering of the sinus (the *sinus plate*) has been exposed and its outline demonstrated. The sinus lies deeply within the mastoid except at its upper and back part, where it lies just beneath the *cortex.*

Mastoid Cells.—The cells of the mastoid process are of 2 general types:

1. Pneumatic.
2. Diploëtic.

The pneumatic cells are large and irregular in shape and normally contain air, and are level with a mucoperiosteum directly continuous with that of the antrum.

The diploëtic cells are small and resemble the cells formed in the diploëtic table of the other cranial bones.

These two kinds of cells are always found in one mastoid, but the mastoid is called pneumatic or diploëtic according to which is the predominating type.

A *sclerotic* or eburnated mastoid is one in which the cells are few or almost absent, and the bone itself is of an ivory-like hardness. This occasionally occurs naturally in certain skulls, but is usually seen as the result of long-continued chronic suppuration.

TECHNIC OF THE SIMPLE MASTOID OPERATION

(*Formerly Called the Schwartze Operation*)

In this operation the operator stands at the head of the patient and the first assistant stands at the patient's occipital side. Opposite the patient's face sits the anesthetist; while the nurse, holding the retractors, stands between the operator and the anesthetist. The operator occasionally changes places with the first assistant when he wishes to work on certain parts of the antrum and dural plate.

Incision.—This is a curved incision starting at the mastoid tip and extending upward in a curved direction parallel to, and about ¼ in. behind, the postauricular fold. It terminates about ⅜ to ½ in. above the superior attachment of the auricle. Theoretically its depth is at once extended to the bone. In practice we usually incise the tissues down to the periosteum below and the temporal muscle above; the parts are then slightly retracted and the incision is extended through these structures in the same line. Some operators attempt to preserve the integrity of the temporal muscle, but I have found that more trauma is caused by the necessary retraction than by a clean cut into its substance. At this point there is usually free bleeding from branches of the posterior auricular artery, but this is usually disregarded until the periosteum has been partly reflected.

The posterior incision is then made. This is horizontal and extends from opposite the center of the auditory canal, directly backward, toward the external occipital protuberance. The length of the incision varies according to the individual needs of the case from ½ in. to 2 in. It extends directly down to the bone.

Some operators prefer to make the posterior incision only if demanded during the operation, giving as their objection the posterior scar formed by its routine use. If carefully made and carefully sutured after the operation, this scar is almost unnoticeable, being partly within the hair line, and the avoidance of strong retraction greatly lessens the trauma and thus the risk of subsequent infection of the flaps so made.

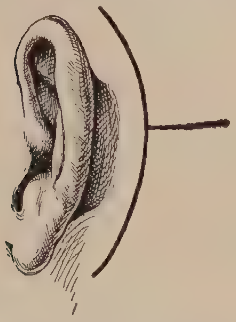


Fig. 10.—Line of Incision for Mastoid Operation.

Elevation of the Periosteum.—It is essential for rapid and proper postoperative healing that the integrity of the periosteum be preserved as far as possible. To this end the periosteum and the overlying tissue of the flaps formed by the above incisions are carefully elevated in one layer.

This is best accomplished by the Langenbeck elevator. It is placed in the line of the periosteal incisions and the periosteum slightly separated by a shoving and hoeing motion with the edge of the instrument held close to the bone. The bleeding vessels which, up to this time, have been partially controlled by pressure, are now clamped and the remainder of the periosteal reflection can proceed in a leisurely and accurate manner. The anterior flap and the upper posterior flap are easily reflected. The lower posterior flap and the periosteum around the tip are more adherent, owing to the insertion into the bone of the fibers of the sternomastoid muscle. These, in females and young subjects, however, can usually be separated by the careful use of the periosteal elevator. In male subjects it is usually necessary to cut them away with the curved scissors. The anterior flap should be reflected until the posterior canal wall and the suprameatal spine are seen. The upper and lower posterior flaps are reflected to the limit of their incisions. The fibers of the sternomastoid should be separated from the bone until the tip can be plainly felt by the finger.

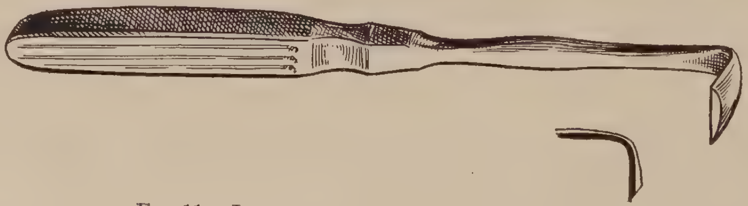


Fig. 11.—Langenbeck's Periosteal Elevator.

The periosteal elevator is held in the right hand and the edge steadied against the bone with the index and middle fingers of the left. The motion imparted to it should be of a diagonal pushing and hoeing character, i. e. in pushing the periosteum, the instrument should go not simply forward, but forward and sideways. (The same is true of the backward hoeing motion.)

After reflection of the periosteum, the surface of the bone should be searched for any fistulæ or sinuses. These, if present, usually are in the neighborhood of the antrum, less frequently found near the tip. If these are carefully investigated, they are usually found to lead to the antrum, thus forming one of the guides to its position. These openings in the bone are not usually large, sometimes barely admitting a medium-sized probe. The site of the fistulæ is usually marked by granulations protruding through the bone. The surrounding bone can be gently pried away with a curet until a large enough aperture is formed to admit a rongeur forceps. The cortex can then be removed with this instrument.

If fistulæ are not present, the next step is as follows:

1. Opening of the antrum; or,
2. Formation of the initial groove.

Opening of the Antrum.—The antrum may now be opened or the initial groove along the anterior border of the bone made, and the antrum incidentally opened *after* curettage of the anterior mastoid cells.

The first procedure is advisable if the operator is inexperienced, for although taking longer, the finding of the antrum gives a definite landmark in the interior of the bone, and after its investigation with a probe considerable information may be obtained, not only as to the dimensions of this cavity, but as to the whereabouts of the dura and sinus.

Opening of the antrum is accomplished by removing the *cortex* of bone within the boundaries of *Macewen's* triangle (see page 115). This is best done by the use of a medium-sized chisel or gouge. In taking the bone away from the upper border, the instrument should be directed downward and inward, and in using the instrument at the posterior border, it should be directed forward and inward toward the auditory canal, and not directly inward toward the interior of the mastoid. This is necessary in order that, if dura or sinus is encountered unexpectedly, the instrument will not plunge directly into these structures, but will pass parallel to them, leaving them exposed but uninjured. Taking small shavings at a time, the cortex is chiseled away until the cellular structure is uncovered. More room will be gained and the above procedure facilitated, if *also* from time to time the cortex be partially removed from the bone surrounding the triangle, above, behind, and below. This can be safely done if the bone be taken away in thin layers and the chisels held as directed. When the cortex is removed, the cellular character of the bone is at once apparent. With a rotary motion, a curet can now usually be used to continue the general direction, forward, inward and slightly upward, close to the posterior canal wall, until at a depth of ¼ to ¾ in., the curet gives the sensation of passing into a rather large cavity, and the antrum is reached. Proof of this is made with a small bent probe, which is passed from the anterior part of the antrum into the aditus and middle ear. If this cannot be done, the chances are that the operator is not in the antrum, but in an adjacent large cell.

FAULTS OF TECHNIC IN OPENING THE ANTRUM.—1. USING TOO MUCH FORCE.—If too much force is used, the operator may plunge directly through the antral cavity and injure the dura on its inner or upper wall.

2. PASSING BELOW THE ANTRUM.—If the operator starts his initial opening too low or continues the opening inward instead of inward and slightly upward, he may pass below the antrum; and if he carries the excavation to an undue depth, may injure the external or posterior semicircular canal. The remedy for this is, if the antrum is not reached at a proper depth, to stop and see if the opening has been continued *in the proper direction.*

3. MAKING THE OPENING TOO HIGH.—If the initial opening be too high, and the direction be too much inward, the dura may be exposed and injured. This should be guarded against by frequently exploring the upper wall and fundus of the excavation with a probe. If the direction is too far forward and not parallel to the general direction of the auditory canal, the middle ear may be entered or the facial nerve or external semicircular canal injured. Usually the operator has no difficulty in finding the antrum. Occasionally in bones of the sclerotic type, the antrum is very small and far forward, and it is found with great difficulty. Cases have been reported of absence of the antrum, but their authenticity is questionable. In the very difficult cases, the following expedients may be adopted.

If the operator has removed the cortex over the area given above, and to a depth beyond which he hesitates to go, for fear of injuring some vital structures, he may reassure himself by the following maneuver. This depends on the fact that the inner wall of the tympanum lies on a level 2 mm. deeper than the antrum (4). A probe is inserted between the fibrous canal lining and the posterosuperior bony canal wall, downward as far as it will go, i. e. to the inner tympanic wall. The depth of this is measured and compared to the depth of the exploratory antral opening. The antral opening may be carried inward until it almost equals the depth measured on the probe. But probably before this the antrum will have been reached. If this is not successful, a probe may be bent at right angles ¼ in. from the end, and inserted as above and rotated so that the bent end passes from the tympanum through the aditus at its upper and back part, into the antrum. The exploratory opening can then be cautiously deepened until the antrum is reached with the probe in situ. In addition to the above, the probe gives valuable information as regards the direction of the auditory canal, and consequently as regards the direction to be pursued in the exploratory opening. While the passage of a probe into the tympanum can be accomplished without much harm, the use of the bent probe is to be reserved as the last resort in cases of extreme difficulty, for its use is apt to cause some disturbance of the ossicular chain with subsequent impairment of hearing. This does not apply in locating the antrum preliminary to a radical operation, for here the ossicular chain will be further deranged by the subsequent operative procedures. When the antrum has been explored with a probe, its overhanging walls should be cut away with a curet and rongeur, and its cell-like cavity itself transformed into a shallow bowl-shaped aperture.

It must be remembered, no matter when or how performed, that the opening and widening of the antral cavity are vital and essential steps in the mastoid operation. It is the keynote to the successful surgery of the mastoid process. After the reflection of the periosteum, if the antrum has not been formally opened, the initial opening or initial groove is made.

Formation of the Initial Groove.—With a wide gouge a strip of bone 3/8 in. wide is now removed from the extreme anterior border of the mastoid, adjacent to the posterior canal wall, extending from just below the root of the zygoma above to the tip below. This strip is just thick enough to include the thickness of the cortex and to expose the cells beneath. These cellular tissues may now be removed with a narrow curet, keeping close to the bony canal wall anteriorly, but lightly undercutting the posterior edge of the groove. If the cellular structure is extremely hard, the use of a narrow gouge is necessary for its removal. In children under 10 years of age this initial opening can be made by a narrow curet, curetting from the tip upward. It must be remembered that the lateral sinus may lie anywhere within the mastoid process, and until it has been definitely located either before operation by the X-ray or at operation by the exposure of its glistening bony plate, one must be continually on the lookout for it and proceed with extreme caution.

After removal of the cortex, the underlying cellular structure must be examined for exposed sinus, and, after the removal of the cellular structure, the posterior boundary must again be examined with the probe.

After the initial opening the operator must answer the following questions:

Is pus present in the initial groove and does it *well up and pulsate?* Pus present in the initial groove indicates a well-marked mastoiditis, and a profuse discharge of pus, pulsating in character, marks disintegration of the interior of the mastoid with an exposure of a considerable area of *dura or sinus.* We can assume that the sinus has not been encountered. The cortex adjacent to the initial groove is now further removed by a broad gouge, care being taken not to disturb the cells beneath. These cells are then cautiously curetted away until we have a groove about 3/8 in. wide, extending from just below the zygoma to the tip, and in depth reaching the inner plate of the mastoid process. Probably at this juncture the antrum has been opened during the above procedure. If so, it should be treated as before noted. If it has not been found, further search for it should be postponed until the removal of the zygomatic cells.

Removal of the Mastoid Tip.—The tip can be conveniently removed at this stage of the operation. Removal of the tip is now conceded to be indicated in every complete mastoid operation in the adult. Exceptions to this sometimes occur in infants and young children. If in doubt, remove the tip. The tip in the pneumatic bones is often almost entirely occupied by one large cell, called the *tip cell.* It is usually the largest cell in the mastoid with the exception of the antrum, and in acute cases is frequently found filled with pus.

The remaining fibers of the muscle should now be cleanly separated from the extremity and inner surface of the tip and extended posteriorly well along the posterior border of the bone.

The facial nerve makes its exit from the stylomastoid foramen anterior to the tip, and in separating the fibers of the muscle from the bone, which is best done with the sharp edge of a large bowl-shaped curet, the instrument should be made to hug the bone closely. The tip should be separated on its inner aspect as far as the occipital groove. It may then be removed as far as the above groove with successive bites of the rongeur forceps, one blade being placed on its inner surface and one on its outer. If any muscle fibers still remain attached to the fragments thus removed, they should be carefully cut and not torn away. The tearing away of attached fragments of the tip opens up pathways of infection in the substance of the muscle and invites a subsequent cellulitis of the neck.

After removal of the tip, the remaining cortex of the bone should be cut away with the rongeur forceps, proceeding cautiously upward and backward until the sinus plate is seen. Our attention should now be directed to the zygomatic cells.

Removal of the Zygomatic Cells and Final Treatment of the Antrum. — The cortex overlying the remaining anterior part of the suprameatal triangle should now be removed. This will expose the zygomatic cells. If the antrum has not already been opened, that should now be done. A medium-sized curet is inserted in the anterior part of the triangle and directed inward, forward and a little upward, and with a boring motion the cells are penetrated until the antrum is reached. The operator should then proceed as directed on page 121. External and anterior to the antrum the zygomatic cells are now removed until a triangular space is formed, bounded above by the dural plate, below by the superior canal wall, and having for its apex a cell with well-marked glistening walls, the *terminal zygomatic cell.* The anterior antral wall is now cautiously removed until its boundaries become continuous with the space above.

The cavity of the antrum must now be inspected and its cavity cleared of granulations *or softened bone.* This is done with a medium-sized curet. In doing this, 3 structures are endangered, and their position must be noted:

1. Facial nerve.
2. External semicircular canal.
3. Horizontal process of the incus.

The facial nerve passes beneath the floor of the aditus. The external semicircular canal lies in its posterior wall, while in front of the anterior part of the semicircular canal lies the horizontal limb of the incus.

All unnecessary cureting should be avoided. In using a curet in the anterior part of the antrum, the bowl should be placed against the floor, and the cavity curetted upward and outward. Usually we take away enough of the anterior antral wall to well expose the external semicircular and occasionally the tip of the horizontal process of the incus. In so doing, part of the superior canal wall is scraped away. The roof of the antrum is now curetted carefully until the hard bone covering the dura is exposed. At times we injure a minute artery lying in a cleft in the posterior part of the *antral roof*. This is easily checked by packing for a few moments with iodoform gauze. The upper part of the mastoid cortex is now cut away flush with the floor of the middle fossa.

Granulations in the middle ear are often seen projecting through the aditus. In the majority of acute cases these will take care of themselves. Some otologists are accustomed to remove them by the cautious use of a small dull ring curet, but the occasional operator had better trust for their removal to the reparative powers of the individual.

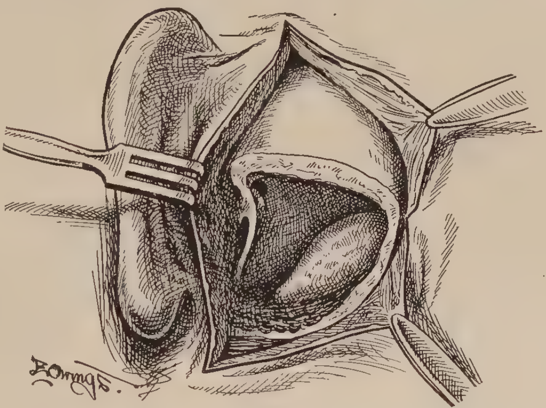


Fig. 12.—Mastoid Operation Completed. The aditus and external semicircular canal are seen in the upper and anterior part of the bony cavity. (From a dissection by the author.)

Sinus Plate.—The sinus plate is now outlined above by gently curetting backward from the posterior part of the antrum until the outlined plates covering the dura and sinus are seen to fuse at the posterior and upper part of the bone. Usually the tissue is diploëtic, but frequently a line of well-marked cells will be found above the sinus, extending backward a variable distance. These should not be opened until the terminal cell is reached.

The cells over the sinus plate are now gently curetted away until its white, hard walls appear. In well-marked cellular subjects, a line of cells is seen extending below and behind the posterior part of the sinus. In exenterating these, the mastoid emissary vein is frequently encountered and wounded. The edges of the cortex are now finally smoothed down with a Richards curet, and part of the posterior canal wall almost to the level of the annulus tympanicus is cut away with small bites of the rongeur forceps and finished with the Richards curet. This allows the tissues of the canal and upper part of the wound to fall inward and helps to obliterate the operative cavity. The cavity is now flushed with salt solution, dried and carefully inspected for any diseased cells previously overlooked. If the operator is satisfied with the operative cavity, the flaps are *ready for suture*.

Exposure of the Dura.—The dura may be accidentally exposed at the time of operation, or may be found exposed as a result of the pathological process. Accidental exposure of the dura by the operator does no harm, provided the dura itself is uninjured. It is an accident to be avoided, if possible, but at times it is justifiable. A collection of pus between the bone and the dura constitutes an *epidural abscess.* Sometimes large abscesses are connected with the mastoid cavity proper by an extremely small opening. This is the reason why at the end of an operation the entire surface of the operative cavity should be scrutinized most carefully.

TREATMENT OF EPIDURAL ABSCESS.—*All necrotic bone* covering diseased dura should be carefully removed with the curet or rongeur. The granulations covering the dura should not be removed, but they should be examined carefully for any fistula leading to the brain substance (see Brain Abscess). The bone should be removed from the periphery of the abscess until the dura begins to take on a healthy appearance.

TREATMENT OF ACCIDENTAL DURAL EXPOSURE. — Detached fragments of bone pressing against the dura should be carefully removed and the bone removed from the periphery of the accidental opening until the bony plate reaches its normal thickness. The policy of leaving a dural opening surrounded by bone of paperlike thinness is one of misguided conservatism. This usually is insufficiently nourished and subsequently dies, necessitating its extrusion and delaying the ultimate healing of the wound, often indefinitely. If one is in doubt as to the subsequent viability of bone covering the dura, it is better to remove it at the time of the primary operation.

INJURY TO THE DURA.—If the dura has been injured, any fragments of bone should be removed, the wound sponged with 95 per cent. alcohol and a piece of iodoform gauze applied over, but not within, the edges of the wound. The prognosis following perforating wounds of the dura is extremely grave.

Exposure of the Sinus.—The sinus may be found uncovered by the pathological process, and its surface covered with granulations. This is frequently the preliminary stage of a sinus thrombosis; if, however, the interior of the sinus is not invaded the case offers a very good prognosis (see Sinus Thrombosis). This is termed a *perisinous abscess,* and should be treated as an epidural abscess, i. e. all thin and necrotic bone removed from over the sinus until at the periphery healthy sinus wall is to be seen. The granulations should not be disturbed. Frequently we see an apparently unhealthy sinus wall that harbors a perfectly healthy sinus.

ACCIDENTAL EXPOSURE OF THE SINUS.—This is always to be avoided. Usually it is of no consequence, but cases have been reported of sinus thrombosis caused by the accidental exposure of the lateral sinus at the time of operation. If exposed, it should be treated as an accidental exposure of the dura.

WOUNDING OF THE SINUS.—This is a serious accident. Though not as serious as injury to the dura, its gravity is in direct proportion to the amount of infective material introduced at the time. The most dangerous wounds are those in which a piece of necrotic bone is carried directly into the lumen of the sinus by the misguided use of a curet. Clean-cut wounds with the chisel or rongeur are less serious. In these the outrushing blood usually washes away the infective material. In these accidental wounds the bone fragment, if projecting into the sinus, should be quickly but carefully removed and the ensuing hemorrhage checked by the application of iodoform gauze pads (see Sinus Thrombosis). When the hemorrhage has been checked, the carious and thin bone should be removed and the case carefully watched for symptoms of *sinus thrombosis.* Many cases, however, escape this unfortunate complication.

Suture of the Flaps.—The mastoid cavity is now flushed with a warm normal salt solution, all fragments of bone and loose bits of tissue are removed and the cavity sponged dry. The upper part of the vertical incision is now closed with interrupted sutures of silkworm-gut down to the level of the dural plate. The posterior incision is closed throughout its entire extent. Care should be taken that these sutures include and approximate the periosteum as well as the overlying skin and subcutaneous tissue. Some authorities advocate closure of the lower part of the vertical incision, but I have found that rarely, if ever, can primary union be obtained, and that these lower sutures often cause a cellulitis of the lower extremity of the wound.

Packing the Operative Cavity.—The mastoid cavity should be lightly packed with 1 in. 5 per cent. iodoform gauze. This is introduced to the bottom of the wound and folded back and forth on itself, so that its removal may be attended with the least amount of trauma to the walls of the cavity.

Packing the Auditory Canal.—I insist that the auditory canal should be firmly packed with a narrow strip of plain gauze. This should be carefully done, the object being to distend the canal to its full lumen without undue pressure on and injury to the drum. This keeps the fibrocartilaginous canal wall in close apposition to the bony canal and prevents subsequent collapse of the fibrocartilaginous canal.

A wide open auditory canal is essential to an intelligent after-treatment of the drum membrane. It affords a good view of that organ and allows a free exit of pus from the middle ear. If this is neglected, a narrow slit-like canal results, through which the pus can only pass with difficulty, and through which only an imperfect view of the drum can be obtained.

After the packing has been inserted the surrounding tissues are cleansed with saline and the usual dressing applied.

Application of the Bandage.—This is a modified figure-of-eight bandage. Its method of application is best understood by studying the accompanying illustrations. The object of the bandage is twofold, first to keep the dressing in place; second to prevent the ear from sagging until the incision has firmly united. This supporting function of the bandage is best accomplished by standing in front of the patient and bandaging from before backward, starting on the affected side.

AFTER-TREATMENT

The patient's comfort will be increased if the outer dressing be changed daily for the first 2 weeks.

The canal packing may be allowed to remain for 4 or 5 days after operation, and then may be removed every other day, or daily, as the discharge from the auditory canal demands.

On the fourth or sixth day after operation, unless pain or high temperature demands its removal sooner, the mastoid packing is removed, preferably under nitrous oxid anesthesia, and from then on the cavity gently packed with balsam of peru gauze, usually changed every 2 or 3 days.

The local after-treatment of a mastoid wound demands care and thought on the part of the surgeon. Space forbids that it be fully considered in this article and I am compelled to give but a general outline of the subject.

The healing is by granulation. This is seen to start in the cavity on about the sixth to the eighth day. Healing is usually complete in 6 to 8 weeks after operation. The patient, however, can, as a rule, resume his or her ordinary occupation after a month. In the latter part of this healing, a crescentic patch of black silk made to tie behind the ear may be conveniently substituted for the bandage. This, in turn, may give way to a collodion dressing.

General Considerations in After-treatment.—PAIN.—There should be but little pain in the mastoid wound after the first 24 hours. Persistent pain after this time usually means either too tight packing or the presence of a complication.

TEMPERATURE.—The postoperative temperature in an adult should be moderate, 100° to 101° F. This should gradually return to normal. Frequently adults run a slight (1° to 2°) temperature for some time after operation. Children usually have a greater reaction, the temperature often rising to 102° to 103.5° F. (rectal).

DISCHARGE FROM THE AUDITORY CANAL.—Too little attention is generally paid to the auditory canal. The discharge usually continues from 1 to 2 weeks. The longer the duration of the case before operation, the longer is the duration of the postoperative discharge. After each dressing, the canal should be syringed with a salt solution or the discharge carefully wiped from the canal. If the discharge persists for more than 2 weeks, the ear should be syringed every 3 hours with a normal salt solution, followed by the instillation of a warm saturated alcoholic solution of boric acid. Careful attention to the condition of the auditory canal and drum membrane will favorably influence the healing of the postauricular wound.

Method of Packing and Dressing.—In packing the mastoid wound, care should be taken to pack under and support the flap, and not pack it down against the bone. This will prevent the formation of an underlying large depression behind the ear. The packing to the bottom of the wound should be continued until the aditus has become closed by granulations or until at least it has ceased to discharge; at the end of this time I can see no further advantage in keeping the wound open.

Attention should be given to the surrounding skin. In children, especially, it is apt to be irritated by the discharge, a dermatitis resulting. This can usually be avoided by the use of protecting ointments (vaselin, zinc oxid ointment, etc.) and the use of alcohol occasionally.

If the granulations lining the wound tend to become too large or flabby, they should be gently curetted or cauterized with a nitrate of silver stick. After each dressing the discharge in the wound should be wiped away with moist cotton sponges. Irrigations of the mastoid wound are unnecessary as a routine and should be resorted to only when the cavity is very sloughy.

Wounds of the Sinus.—If the sinus has been injured during the operation, it should be covered by a separate piece of iodoform gauze. This should be distinct from the general mastoid packing. It should be left in situ for at least 4 days, better 6. If at its removal at the end of 4 days, bleeding recurs, the packing must be replaced and allowed to remain for another 4 days. If the bleeding does not recur, the separate gauze may be omitted.

Exposure of the Dura.—Exposure of the dura calls for no special after-treatment.

Wounds of the Dura.—If the dura has been accidentally wounded during the operation, the gauze that has been applied should be left in situ for 4 to 6 days if possible. It should then be gently removed, if there is no escape of cerebrospinal fluid; the wound may be treated in the usual manner. A separate piece of gauze should be gently packed over the dural wound as long as the fluid escapes, and great care should be taken in the dressings to prevent infection of the meninges.

Delayed Healing.—The cases of delayed healing usually arise from 3 causes.

1. Continued suppuration in the middle ear.
2. Bare or necrotic bone in the mastoid cavity.
3. Any general constitutional defects.

1. CONTINUED SUPPURATION IN THE MIDDLE EAR.—The discharge from the middle ear in the average case should stop 1 to 2 weeks after operation. Discharges of a longer duration than this, but finally stopping, occur in the cases of mastoiditis that have run a long time before operation. A profuse purulent discharge persisting in the middle ear a month or 2 after a simple mastoid operation usually indicates that caries or necrosis has occurred in that cavity and will not heal by drainage. A radical operation will probably be indicated. In these cases the discharge passes not only through the opening in the drum membrane, but also backward into the operative mastoid cavity, reinfecting the granulations and delaying, if not at times preventing, postauricular healing.

2. BARE OR NECROTIC BONE IN THE MASTOID CAVITY.—There are a certain number of cases where the *middle ear heals promptly* and the hearing

returns, but the postauricular wound remains open at some point. If these are examined with a probe, bare or roughened bone will be found. If constitutional causes can be excluded, this defect will be found to be due to one of 2 causes, either some carious bone has been overlooked by the surgeon, or else the bone has died after the operation, due to the impairment of its blood supply. This last happens when extremely thin layers of bone are left covering the dura or sinus. In many of these cases, if the defect be small, nature will finally throw off the bone and effect a cure. In others, the process may be hastened by a gentle curettage of the rough spot under local anesthesia. In many, however, a reopening of the mastoid wound under general anesthesia is required, when the roughened bone can readily be removed.

3. GENERAL CONSTITUTIONAL DEFECTS.—In hospital cases especially, delay in the healing process is caused by a general run-down condition of the patient, due to poor surroundings or previous illnesses. Many of these cases are anemic. Others suffer from syphilis, tuberculosis, gout, rheumatism, or cardiac or renal trouble. In these cases the granulation of the wound progresses favorably for a few days, and then suddenly stops; the bone may or may not be entirely covered with granulations. A clew to the condition is gotten by a careful examination of the patient's general condition. At this point it is appropriate to emphasize the fact that healing of the granulating mastoid wounds depends not only on local treatment, but on careful attention to the patient's general condition.

Many cases of delayed healing are due to the presence of adenoids and enlarged tonsils. If marked, these should be removed as soon as the temperature becomes normal.

PROGNOSIS OF SIMPLE MASTOID OPERATIONS

In uncomplicated cases, operated upon sufficiently early, the surgeon expects to obtain perfect healing of the postauricular wound with good hearing.

Mortality.—Excluding complications, there should be no operative mortality.

POSTOPERATIVE COMPLICATIONS

1. Cellulitis of the flaps.
2. Erysipelas.
3. Postoperative pneumonia.
4. Sinus thrombosis.
5. Leptomeningitis.
6. Brain abscess.
7. Acute labyrinthitis.
8. Facial paralysis.

Postoperative complications following operations for acute mastoiditis are the exception rather than the rule. In competent hands, the majority of the cases make a smooth and uninterrupted recovery.

Some complications, such as sinus thrombosis, brain abscess, and leptomeningitis, while many times apparently postoperative, in reality, have existed undiagnosed at the time of the original operation.

A cellulitis of the flaps is not rare, and is due to the infection of these tissues by the virulent pus in the interior of the mastoid. Infection is always more frequent after undue trauma of the flaps.

Postoperative erysipelas occurs especially in the streptococcus infections, and is usually due to the peculiar nature of the ear infection rather than to any breach of aseptic technic on the part of the operator.

THE BLOOD-CLOT DRESSING

This method was first advocated by Dr. Clarence J. Blake in 1891. In this country Dr. Blake and Dr. H. O. Reik, of Baltimore, have been the chief sponsors for this method of dressing. In a hundred cases of acute mastoiditis, Reik claims about 75 per cent. healed by primary union.

In this method the operative cavity is rendered as aseptic as possible, allowed to fill with blood, and the posterior wound sutured.

Infection is overcome by: (1) the preparation of the cavity and (2) by the bactericidal property of the clotted blood.

In a recent paper C. R. Holmes (2) has reported 17 cases treated by this method: 3 cases broke down completely, necessitating reopening of all the wound; in 7 cases it was necessary to open the lower angle of the wound; in 7 cases (41 per cent.) there was complete primary union. He maintains that in this method the cases are completely healed in from 3 to 4 weeks. In brief, his method is as follows:

The mastoid antrum and cells are carefully cleaned away in the usual manner. A large incision is then made in the drum membrane and the middle ear carefully syringed. The mastoid wound is sponged dry and filled with hydrogen peroxid, then sponged dry again. This is repeated 3 times, after which it is syringed with 50 per cent. alcohol and the alcohol is allowed to remain in the cavity for 3 minutes. It is then thoroughly dried. To neutralize the alcohol and to enhance the action of the clot by increased alkalinity, the cavity is finally flushed with a solution of sodium bicarbonate and dried. The posterior auricular artery is now opened and the cavity is allowed to fill with fresh arterial blood. The artery is twisted or ligated. The periosteum is now sutured in a separate layer and the skin approximated with "Michel clamps." Subsequently, if there are evidences of infection, the posterior wound must be partially or wholly opened.

Advantages.—The advantages are:

1. Rapid healing.
2. Avoidance of painful dressings.

Disadvantages.—The disadvantages are:

1. Possibility of infection and cellulitis of wound.
2. Decreased drainage of the middle ear, i. e. antral drainage is lost.
3. Possibility of causing intracranial complications.

Contra-indications.—The contra-indications are:

1. Cases of sinus thrombosis, brain abscess, meningitis.
2. Cases of suspected intracranial complications.

Conclusions.—As far as I know, no results have been published as regards the effect of the blood-clot dressing upon subsequent hearing. Certainly the great factor in aiding resolution of the middle ear, i. e. antral drainage, is lost.

This method may be tried by the experienced otologist, but I cannot commend it to the occasional operator, unless to heal a normal mastoid opened under a mistaken diagnosis. (I do not approve of this method.—Editor.)

RADICAL MASTOID OPERATION

The radical operation is performed in suppurative processes of the middle ear and mastoid, in which (i. e. the chronic suppuration) there are considerable caries and necrosis either in the small bones or in the walls of the middle ear. These cases will not resolve by increased drainage of the middle ear as do the acute suppurations, but require more radical treatment.

The radical operation consists first in the opening of the mastoid antrum and the removal of all diseased tissue in the mastoid process; secondly, in the removal of the upper posterior quadrant of the bony canal wall; third, in the lowering of the remaining lower segment of the posterior canal wall without injury to the facial nerve; fourth, removal of the outer walls (drum and bony frame of the middle ear) and curettage of the necrotic tissues and eustachian tube; fifth, in the formation of a plastic flap to enlarge the fibrous auditory canal and to allow for easy dressing and exit of the secretions.

Thus, in every case of mastoiditis requiring operation, it is of prime importance to **ascertain whether the mastoiditis is secondary to an acute or chronic suppuration of the middle ear**, in order that we may know whether to perform a simple mastoid or a radical operation.

Before deciding upon a radical operation it is necessary to determine the reaction of the semicircular canals to the heat, rotation and fistula tests, and the cochlea to the absolute hearing test, in order to rule out a latent diffuse suppurative labyrinthitis. If this is present the labyrinth must be opened and drained at the time of the radical operation. Many cases of meningitis have been caused simply by performing a radical operation on a patient who is also suffering from an unsuspected diffuse purulent inflammation of the labyrinth.

Indications for the Radical Operation.—1. In simple uncomplicated cases of chronic purulent otitis media that resist prolonged, skillful local treatment, in which the patient desires complete relief from the discharge.

2. A chronic discharge from the middle ear, accompanied by poor or failing health, other causes being excluded. These cases are seen especially in children.[1]
3. Persistent acute exacerbations of a chronic suppuration accompanied by pain or mastoid tenderness.
4. Recurring polyps arising from any part of the middle ear, especially the promontory, antrum, or attic.
5. A fistula from the mastoid cells to the cortex or posterior canal wall.
6. Cases of cholesteatoma resisting local treatment.
7. Fetid suppuration, resisting long-continued treatment.
8. Paralysis of the facial nerve.
9. Chronic suppuration of the middle ear, exhibiting symptoms of suspected sinus thrombosis, chills, high temperature.
10. Chronic suppurations of the middle ear, showing symptoms of beginning intracranial involvement, headache, nausea, vertigo, vomiting.
11. Chronic suppurations of the middle ear, with an intractable stenosis of the auditory canal.
12. Certain cases of impacted foreign bodies in the middle ear, to facilitate their removal.

ANATOMICAL POINTS TO BE NOTED

1. **Facial Nerve.**—It is of the utmost importance for the operator to familiarize himself with the surgical relations of the facial nerve in the temporal bone. Briefly, the facial nerve passes outward from the internal auditory canal until it reaches the anterior and upper part of the inner wall of the middle ear, just above and posterior to the canal for the tensor tympani muscle. It then passes backward in the inner wall of the middle ear, above the foramen ovale, until beneath the floor of the aditus, when it bends, to descend almost vertically (see page 146) in the posterior canal wall, to emerge from the bone at the stylomastoid foramen. The anterior part of the external semicircular canal bears an important relation to the vertical part of its course. It juts outward, i. e. toward the operator, over the facial nerve, as does the eave over the corner of a house, so that in lowering the posterior canal wall, we can remove the bone until we reach an imaginary vertical line dropped downward from the convex prominence of the external semicircular canal. The nerve runs in a canal of hard bone, the *aqueductus Fallopii.* This is thinner, and the nerve more liable to injury in the horizontal part of its course on the inner wall of the middle ear than in the vertical part of its course in the posterior canal wall.

2. **Character of the Bone.**—In many cases of long-continued suppuration requiring a radical operation, many if not all of the mastoid cells have become

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[1] There is no question but that in certain cases there is enough absorption of the chronic discharge to markedly impair the general health, and in young children to unfavorably influence the growth and development.

obliterated, the antrum cavity narrowed, and the bone has assumed a dense ivory-like character. In the cholesteatoma cases, on the contrary, the bone beneath the cortex is apt to be soft and the natural cavities of the ear and antrum enlarged by the erosive quality of the cholesteatomatous *masses.*

3. **External Semicircular Canal.**—This is covered with hard, dense bone whose whiteness usually affords a marked contrast to the surrounding tissue. It should always be sought for after opening the antrum. Its relation to the antrum has already been noted (see page 116).

4. **Lateral Sinus.**—As previously noted, its position is extremely variable (see page 116). In cases requiring a radical operation, the sinus is quite apt to be far *forward.*

5. **The Foramen Ovale and Rotundum.**—These foramina lie in the posterior part of the inner wall of the middle ear, just anterior to the junction of the inner wall and posterior canal wall. They are partly covered by the overhanging canal wall. The foramen ovale, lying just beneath the turn of the facial nerve, cannot be plainly seen during the radical operation unless the facial ridge (see page 136) has been lowered to its extreme limit. Even then it is usually covered by a mass of granulations which should not be disturbed.

6. **The Promontory.**—This is the rounded prominence on the inner wall of the middle ear anterior to the foramina ovale and rotundum, and is the bone covering the first and second turns of the cochlea.

7. **Eustachian Tube.**—The opening of the eustachian tube is seen in the anterior part of the middle ear, in the niche formed by the anterior and inner wall, about 3 or 4 mm. above the floor.

In curetting the eustachian tube, its relation to the carotid artery must be remembered. The internal carotid artery lies to the inner side and below the eustachian tube, separated from it by a thin plate of bone. This bone often contains dehiscences, and injury of the carotid artery may be caused by rough or incautious curettage of the tube.

8. **Canal for Tensor Tympani Muscle.**—This lies parallel to and just above the eustachian tube. The bony partition between the 2 canals is often more or less incomplete. Emphasis will be laid on this in connection with curettage of the eustachian tube (page 138). The horizontal part of the Fallopian canal lies above and just behind the *canal* for the tensor tympani, and it is in this locality that the bony wall is extremely thin and that the nerve is liable to be injured.

9. **Glenoid Fossa.**—This lies on the anterior surface of the plate of bone forming the anterior bony canal wall, and in widening the canal this is sometimes entered. As a rule, the articular cavity of the jaw is not injured and no harm results, aside from a slight temporary soreness and stiffness of that articulation. If the synovial cavity is injured, a serious septic arthritis may ensue.

10. **Jugular Bulb.**—The jugular bulb is in relation to the floor of the middle ear. Cases of injury during the course of a radical operation have been

reported, but it is an uncommon accident. In rare instances, there is a congenital defect of the floor, and the bulb lies in the floor of the middle ear, unprotected by a bony plate and liable to injury even with the most careful use of the curet.

11. Tegmen Tympani.—Above, the middle ear is separated from the temporosphenoidal lobe of the brain by a thin plate of bone, the tegmen tympani.

TECHNIC OF THE RADICAL MASTOID OPERATION

It is convenient to perform the radical operation in the following steps:

1. Incision.
2. Reflection of the periosteum and separation of the fibrous auditory canal.
3. Preliminary removal of bone over outer wall of attic, posterior canal wall and antrum.
4. Opening of antrum and removal of mastoid cells.
5. Removal of the posterosuperior quadrant of the bony canal wall.
6. Lowering of the facial ridge.
7. Removal of outer wall of attic.
8. Obliteration of hypotympanum and widening of the bony canal.
9. Curettage of eustachian tube.
10. Formation of plastic flap.
11. Suture of posterior wound and flap.
12. Dressing.

1. Incision.—The usual mastoid incision is made (see page 99) ¼ in. behind the postauricular fold, and extending from the tip below to ¼ in. above the superior attachment of the auricle. In certain cases it is advantageous to prolong this somewhat upward and forward.

Some operators advocate a more convex incision with its apex almost 1 in. posterior to the postauricular fold. This makes in many instances a more conspicuous scar, and the advantages claimed for it do not, in my opinion, compensate.

The horizontal incision is rarely necessary, and is not made as a matter of routine.

2. Reflection of Periosteum and Separation of Fibrous Auditory Canal.—The periosteum is now reflected in the usual manner and the lining of the bony canal separated throughout its entire circumference with a medium-sized curet, tearing it away from the membrana tympani (if any remains) at the annulus tympanicus. All bleeding vessels are clamped and the posterior edge of the wound held apart with the sharp retractor, while the Whiting retractor is inserted into the auditory canal.

I have never seen any ill effect from the separation of the entire circumference of the auditory canal,[1] and the added space and clear view of the auditory canal gained by this step are of great advantage to the operator.

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[1] Some authors leave the anterior part attached to avoid necrosis of the canal wall.

3. **Preliminary Removal of Bone Over the Outer Wall of the Attic, Antrum, and Posterior Canal Wall.**—The cortex over the above regions is removed to the depth of about 1/8 in. and to the extent shown in the accompanying figure. This is cautiously done with a medium-sized gouge. In cases where the cortex is thick this enables the subsequent work on the antrum and canal wall to be accomplished with greater facility. With a little experience this can be done quite rapidly. In children with soft bones this step may be omitted. Before removing the cortex the occasional operator should always preserve in his mind's eye the location of the boundaries of the supra-meatal triangle.

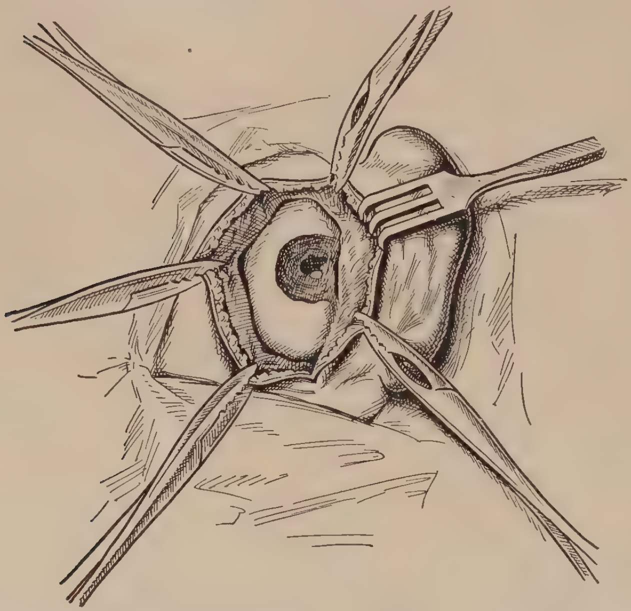

FIG. 13.—RADICAL OPERATION (1). Opening of the antrum, showing external semicircular canal at the bottom of the cavity.

4. **Opening of the Antrum and Removal of the Mastoid Cells.**—The method of opening the antrum has been given under the Simple Mastoid Operation (page 111). In chronic cases, however, the following peculiarities are usually noted, which render the step more difficult: (a) hardness and thickness of the cortex; (b) the apparent depth; (c) smallness of the antrum. The keynote in this procedure is to proceed slowly, hug the posterior canal wall and proceed in a direction inward, forward and a little upward. When opened, the antrum should be identified by means of a probe and its overhanging walls removed. The dural plate, and if necessary the sinus plate behind should be identified above. In a chronic case always be on the lookout for a low dura and a far forward sinus. Usually the mastoid cells are few in number. The bone, if not sclerotic, is usually diploëtic in character. All suspicious or doubtful bone in the mastoid should be removed. While we wish to avoid, if possible, a large mastoid cavity, it is safer in the long run to remove any bone that seems even slightly diseased, removing the tip, if necessary. The bone in the zygomatic region is now removed either with a gouge, or a Richards curet, which is worked from within outward, using the posterior tip of the bony opening as a fulcrum. This serves to *narrow* the ring of bone at the posterosuperior canal wall. In this step the external semicircular canal should

be identified. On account of the ivory-like character of the surrounding bone, it usually is not as conspicuous as in the acute cases.

5. **Removal of the Posterosuperior Quadrant of the Bony Canal Wall.**—A probe is now passed from the antrum through the aditus into the middle ear. All the canal wall above and external to this probe may be removed in the following manner: It is assumed that the outer wall of the antrum has been removed completely so that the upper border of the antral opening is flush with the dural plate, and that the periphery of the upper and posterior part of the canal wall has been outlined by the removal of the bone covering the zygomatic area, together with any zygomatic cells that may be present. This removal of bone in the zygomatic region decreases the anteroposterior dimensions of the bone to be removed and renders the final removal of the bony ring easier and less dangerous to the facial nerve which lies beneath and below.

The outer portion of the posterior canal wall, i. e. approximately one-third, may be removed with the rongeur and the remainder with the chisel, or the entire segment with the chisel in the manner described below:

With a sharp, medium-sized Whiting chisel a vertical cut 1 mm. in depth is made into the bone of the posterior canal, just below the level of the dural plate, the chisel being held with the flat edge toward the dura; starting below at the level of the canal floor, a layer of bone is shaved from the posterior canal wall, *meeting* the vertical incision above, the chisel now being held with the beveled edge toward the bone. Thus a wedge-shaped shaving will be taken from the posterior canal wall, thin below and thicker above, its base corresponding to the depth of the vertical incision. This process is repeated until all that remains of the upper posterior wall is a thin bony bridge with the antrum posterior and above, the cavity of the middle ear anterior and below.

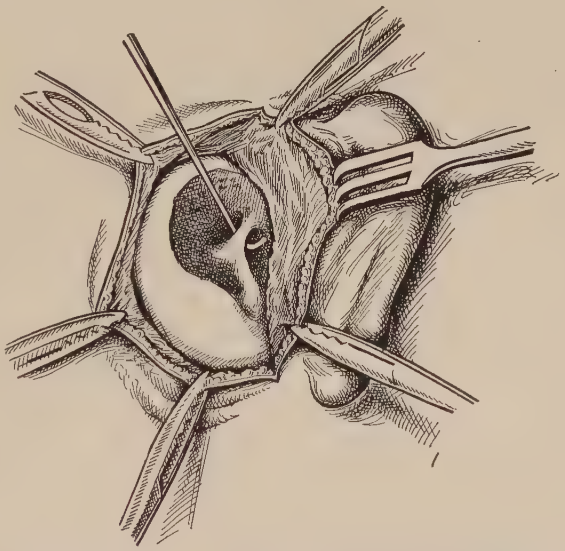

FIG. 14.—RADICAL OPERATION (2). Showing "bridge." The probe is passed from the aditus, beneath the bridge, into the cavity of the middle ear.

By this method, it will be seen that the chisel is driven vertically inward only above the level of the facial nerve, while the chisel when lowering the lower part of the canal wall is held almost parallel to the nerve, reducing to a minimum the chance of injury by a slip of the instrument.

The remaining bridge of bone is now thinned from behind by the cautious use of a small Richards curet, and may be removed by one of 2 methods:

(a) It may be bitten away in one piece by the Jansen forceps, care being taken not to twist the instrument while this is being done.

(b) Or, a small chisel may be placed at its upper extremity, and smartly tapped; in this method the bridge may be fractured above and below without the fracture line extending into the Fallopian canal and injuring the nerve. If a chisel is used at the lower extremity of the bridge, injury to the facial nerve is apt to result.

The remainder of the canal wall forms the so-called facial ridge. At its upper and anterior extremity is now seen a small spur of bone, the remains of the *annulus tympanicus*. Directly below and beneath this are the stapes and foramen ovale, while at its inner side lies the facial nerve. This spur must be cautiously shaved down until completely obliterated. This is done with the side of a curet, working from above, using the upper edge of the bone cavity as a fulcrum.

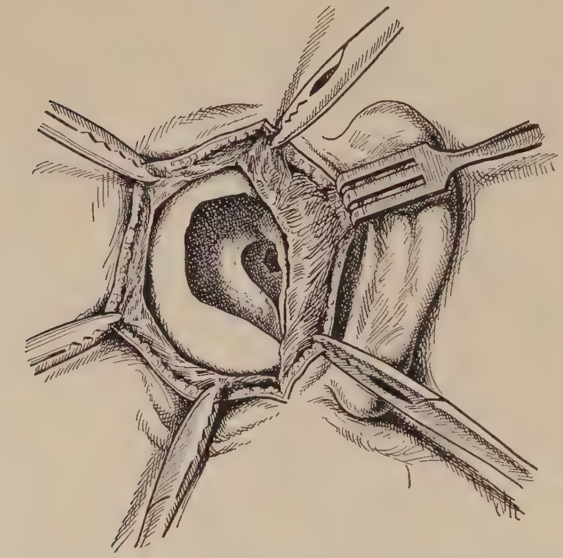

Fig. 15.—Radical Operation Completed. The cavity of the antrum and middle ear are seen converted into one. The eustachian tube is seen at the anterior part of the bony cavity.

6. Lowering of the Facial Ridge.—The facial ridge must now be lowered until it reaches an imaginary vertical line dropped (with the patient in the upright position) downward from the convexity of the external semicircular canal. This is best accomplished by the use of a large-sized Richards curet, working from above and using as before the upper edge of the bone cavity as a fulcrum. At the base of the ridge, nearing the floor of the auditory canal, a sharp Whiting's gouge used in the hand will be found more efficient than the curet. With these two instruments the bone should be taken away in thin shavings, the face being closely watched by the anesthetist for twitching which denotes that the facial nerve is in dangerous proximity. If the facial ridge is lowered to the extreme limit of safety in the manner described, the facial artery, which lies in the general course of the nerve, but somewhat external to it, will be divided. This is a very small vessel and the resulting hemorrhage is easily checked by pressure.

7. Removal of the Outer Wall of the Attic.—The outer wall of the attic, if any remains after the preliminary removal of bone (see page 134) and after the cutting away of the posterosuperior quadrant of the canal wall, is now removed so that the outer border is on a level with the highest point of the attic cavity and there is no *overhang*. Especially important is it to remove the overhang at the junction of the anterior and outer walls of the middle ear. This may be done with a medium-sized curet, using the side of the instrument, and working from within outward. Oftentimes in this region the dura has been exposed by the pathological process. If so, it should be treated as in the simple mastoid operation.

The contents of the middle ear cavity, which probably consist of granulations and necrotic ossicles, may now be removed by the gentle use of a curet, inserting the instrument into the cavity and curetting gently outward away from the promontory and foramen ovale. After this is done the cavity is packed for a moment with gauze saturated with adrenalin 1:1,000. This checks the oozing and makes the bony landmarks more prominent.

8. **Obliteration of the Hypotympanum.**—In many of the cases requiring a radical operation, the bony canal wall has become narrowed by a thickening of its lumen following the chronic suppuration.

It is essential for good drainage and perfect healing that the distance between the anterior canal wall and facial ridge be made as great as possible, for the granulations have a tendency to bridge across this space. This is accomplished by:

(a) Removal of the facial ridge to its lowermost limit.
(b) Thinning of the anterior canal wall.
(c) Obliteration of the hypotympanum.

The facial ridge has been considered in the preceding paragraph.

The anterior tip of the eustachian tube and canal wall may be thinned with a small curet, starting at the orifice of the eustachian tube and proceeding outward. This should be done until the convexity of the bone external to the tube has been entirely removed.

Roughly, the hypotympanum is that part of the middle ear cavity lying below the floor of the bony canal. This overhang (i. e. the outer wall of the above cavity) should be removed so that the canal floor is on a level with the lowermost part of the tympanic cavity. It is necessary to pay especial attention to the overhang at the junction of the base of the facial ridge and the posterior part of the hypotympanum. This is a point in the operative technic that is frequently neglected, and its omission is a factor in a certain number of postoperative failures.

In this locality the facial nerve, instead of proceeding vertically downward, turns somewhat backward, so that the overhang may be cautiously removed without danger to its integrity. This is done with a small No. 0 Richard curet, supplemented by a Whiting gouge, and by scraping from within outward. When the hypotympanum has been completely obliterated, a probe may be passed from the junction of the inner wall and the floor directly outward without encountering any ridge of bone.

9. **Curettage of the Eustachian Tube.**—The mucous membrane must now be removed from the interior of the eustachian tube as far down as the isthmus. Failure to do this often results in a permanent communication with the throat; accompanied by an intermittent or continuous discharge and by the constant liability of the operative cavity to a reinfection. This is best done by the use of the Yankauer curets. While not designed by Yankauer for use in the radical operation, I have used them constantly for that purpose, since their introduction, and have found them most efficient. If these are not at hand, a very small Volkmann curet may be used in their stead. Some operators prefer a hand-burr.

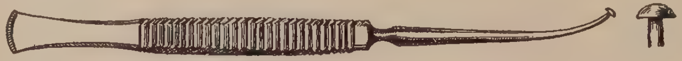

FIG. 16.—YANKAUER EUSTACHIAN CURET SHOWING DETAIL OF HEAD.

Again I must emphasize the relationship of the carotid artery, i. e. its position, to the lower and inner side of the tube. Often a group of cells is found extending from the aural opening of the tube to the hypotympanum. These, if present, must be removed. If cells are not present in this locality cancellous bone may be found; this should be removed with a curet until the walls are smooth and hard.

The canal for the tensor tympani runs just above and parallel to the eustachian tube. The bony partition between them should be broken down with a curet and the 2 tubes made into one for as great a portion of their length as is possible. This allows their lumina to fill up with granulations and eventually to be obliterated.

Failure to treat adequately the eustachian tube and the canal for the tensor tympani muscle is responsible for a persistent discharge in many cases upon whom the radical operation has been performed.

When this step has been accomplished the cavity is flushed with a normal saline solution and dried. It is then inspected carefully to make sure that the operator has not overlooked any diseased area either in the middle ear or in the mastoid process. If these are found they should receive appropriate treatment. The area of the promontory and foramen ovale should be excepted. In my opinion curettage of this area is not only unnecessary in cases requiring simply a radical operation, but fraught with danger. Rough and improper treatment of the promontory and meddling with the foramen ovale have without doubt been responsible for a certain number of cases of acute labyrinthitis following the radical operation. Granulations over these areas should not be disturbed. If the rest of the operative cavity be properly exenterated the surgeon need feel no uneasiness as regards the resolution of the tissue in this area. Of course this does not apply to cases where a labyrinthitis is present (see Labyrinth Operation).

10. **Formation of a Plastic Flap.**—The purpose of this step is twofold: first, to enlarge the external auditory canal so as to allow of subsequent dressings through its lumen; second, to utilize the skin of the canal in lining the operative cavity. Various plastic operations have been devised for this purpose; however, I describe one which is simple and admirably fulfills its function.

This consists of two incisions, meeting each other at right angles, a vertical one in the concha and a horizontal one in the floor of the canal. The sharp flap knife is taken and thrust through the concha at *a*, and carried downward in a curved direction just outside the line of junction of the concha with the canal until it reaches *b*, the junction of the concha with the floor of the canal. This incision extends through the entire thickness of the concha. The size of the future canal can be governed by the distance of the incision behind the conchomeatal junction. We usually plan to make a canal through which we can pass the tip of the little finger. Too large a meatus causes undue disfigurement.

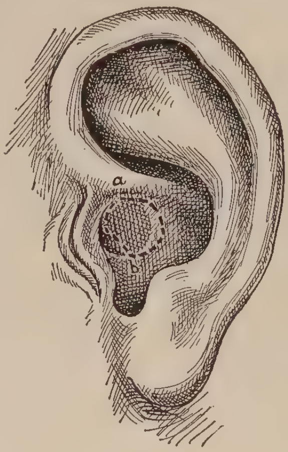

Fig. 17.—Radical Operation Showing the Lines of Incision for the Formation of a Plastic Flap.

The flap is completed by a second incision extending directly inward from *b* along the floor to the innermost extremity of the canal. This is conveniently made by inserting the probe-pointed flap knife into the lowermost part of the vertical incision from behind, and severing the floor of the canal. The flap thus formed is pulled upward and backward, the cartilage removed from its surface with the scissors, and sutured to the fascia covering the temporal muscle, so that when the auricle is in its proper position the flap lies smoothly against the upper part of the operative cavity. If the dura has been exposed, care should be taken that this flap does not lie against it.

11. **Suture of the Posterior Wound.**—It is desirable, if possible, to close the posterior wound. Michel clamps or silkworm-gut sutures are used.

The lower part of the posterior incision should be left open in the following conditions:

1. Large mastoid cavity.
2. Exposure of a considerable area of dura or sinus.
3. Cases of cholesteatoma.
4. In cases of suspected intracranial complications.

Before the posterior wound is sutured, the cavity should be lightly packed through the auditory canal with 5 per cent. iodoform gauze.

INJURY TO THE FACIAL NERVE

During the entire performance of the radical operation the anesthetist should carefully watch the face of the patient for twitching of the eye and face which denotes that the surgeon is in dangerous proximity to the facial nerve. If this is seen, he should at once warn the operator.

In the ordinary radical operation the facial nerve should not be injured by the careful operator. If the nerve has already been exposed in its course by the pathological process, slight injury is sometimes unavoidable.

Facial paralysis is of two kinds: first, that caused by injury to the nerve at operation; this paralysis appears immediately after operation, its extent and prognosis depending upon the amount of injury inflicted; second, that caused by a traumatic or a pressure neuritis without actual injury to the integrity of the nerve itself. This may often be caused by the removal of necrotic bone in close proximity to the nerve or the use of too tight postoperative packing. In the latter case the paralysis appears only at an interval of 24 to 48 hours after operation, is almost never complete and may disappear in a few days, or as late as 3 months after its onset. In these cases the paralysis is rarely permanent and need cause the operator but little anxiety. The most frequent sites of these injuries are not, as is commonly supposed, along the facial ridge, but in one of two places: first, where the facial nerve enters the middle ear above and behind the canal for the tensor tympani; second, at the posterior part of the hypotympanum where the facial ridge joins the inner part of the floor of the bony canal.

AFTER-TREATMENT

The primary packing is removed on the third to the fifth day after operation and then dressed every other day with either balsam of Peru or 5 per cent. iodoform gauze. When the cavity is covered with granulations, usually in about 2 weeks, the packing may be omitted. The ear is then irrigated once or twice a day to remove the discharge and the cavity treated by the instillation of a warmed solution of boric acid in alcohol. Exuberant granulations should be removed from time to time either with a sharp curet, or by cauterization with a chromic acid bead, in order that the operative cavity shall present a smooth even surface for epidermization. By this method the operative cavity finally heals by the epithelium growing in from the edges of the canal and finally covering the granulations.

At times the healing period may be hastened by the use of Thiersch's grafts.

Skin Grafting Following the Radical Operation.—In suitable cases the process of healing after a radical operation may be hastened considerably by the application of Thiersch's grafts to the operative cavity.

While some operators apply grafts to the freshly operated cavity with some success, I feel on account of the complications (meningitis) which I have observed following this practice, that it is safer to use only secondary grafts applied one week to ten days after the operation.

TECHNIC OF SKIN GRAFTING.—In the following description of the technic I wish to acknowledge my indebtedness to a paper by Mr. Chas. F. Ballance (2).

"After an interval of eight to ten days after operation the posterior wound is reopened and the cavity gently curetted. All bleeding is arrested and the cavity cleansed with peroxid Sol. and flushed with saline. The grafts are now cut preferably from the inner surface of the thigh. *They should be large and thin.* They may be kept on plates of glass or they may be immediately carried to the wound on a microscope section lifter. The front border of the lifter is placed against the outer or superficial edge of the anterior wall of the cavity in the bone made by the operation. The margin of the graft is now coaxed from off the lifter on to this superficial edge, and also above on to adjoining superficial edge of the roof of the cavity, just below the linea temporalis. The upper and anterior margins of the graft thus placed are held in position by a probe. The section lifter is gradually withdrawn and the lower and posterior edges of the graft dropped against the posterior and lower boundaries of the operative cavity. The graft there bridges over the operative cavity. The air and blood which separate the graft from the inner wall of the tympano-antral cavity are removed by a little skillful manipulation, but chiefly by suction through a pipet, insinuated beneath the edge of the graft so that it clings closely to the contour of the operative cavity. The graft is now held flat by atmospheric pressure against (1) the anterior wall of the cavity formed internally by the anterior boundary of the tympanum and attic and externally by the anterior wall of the enlarged osseous meatus; (2) the anterior part of the roof of the cavity formed by the tegmen-tympani and the superior wall of the enlarged osseous meatus; (3) the inner walls of the attic and tympanum; (4) the tegmen-antri; (5) the tuberosity formed by the horizontal semicircular canal and the Fallopian canal; and (6) the inner wall of the antrum. A little bleeding is apt to come from the neighborhood of the Eustachian tube and the pipet may have to be used more than once. It is undesirable to graft the posterior and lower part of a very large mastoid cavity, for this will make the permanent cavity unnecessarily large. The main effort should be directed to covering the tegmen, the inner wall of the attic, the tympanum and the antrum."

"The graft is held against the bone with small plugs of cotton, dusted with aristol. The first plug is placed in the lower part of the tympanum and often extends into the upper part of the Eustachian tube; the next is placed against the upper part of the inner wall of the tympanum and attic; and the next against the inner boundary of the aditus and antrum. About seven plugs are usually employed. One or two grafts are also placed on the inner surface of the mastoid flap, corresponding in extent to the tympanum, attic and antrum. These grafts should be arranged so as to cover the raw edge of the posterior margin of the meatus. They thus are inveigled through the meatus and appear on the skin surface of the concha. The mastoid flap is replaced and sutured. A small gauze mop is placed in the meatus to support the grafts against its edge and a dry sterile dressing applied. This should be changed daily and the plugs removed from the third to the sixth day, depending upon the presence of discharge, pain or fever. The dead part of the graft comes away, leaving a smooth pink surface, which rapidly becomes pearly gray. The subsequent treatment consists of gently removing the secretion daily with a dilute solution of hydrogen peroxid and applying a dusting powder. In the favorable cases healing is complete in two or three weeks."

PROGNOSIS AFTER A RADICAL OPERATION

In simple uncomplicated cases we should expect a cure (i. e. a perfectly epidermatized dry ear in 80 to 90 per cent. of the cases). The percentages of failures, if we exclude those due to poor operative technic, occur among patients the subjects of syphilis, tuberculosis, diabetes, arteriosclerosis, or some other constitutional disorder, or in cases following scarlet fever, measles or diphtheria. In the cholesteatoma cases a recurrence is not infrequent, and from time to time the cholesteatomatous masses may be removed from the operative cavity.

In the simple uncomplicated cases the mortality *should be almost nil.*

COMPLICATIONS FOLLOWING THE RADICAL OPERATION

1. Facial paralysis.
2. Cellulitis of the flaps.
3. Sinus thrombosis.
4. Cerebral or cerebellar abscess.
5. Acute meningitis.
6. Acute labyrinthitis.
7. Postauricular fistula.

Facial paralysis has already been considered. Cellulitis of the flaps occurs especially in those cases in which the posterior wound has been sutured throughout its entire extent.

Sinus thrombosis, meningitis and brain abscess sometimes apparently follow the radical operation, but in the majority of cases they have been present, undiagnosticated, at the time of the original operation. They may also be caused by the accidental injury to the brain or sinus at the time of operation.

Acute labyrinthitis may be caused by an accidental dislocation of the foot plate of the stapes or a perforation of the fenestrum ovale. A postauricular fistula sometimes persists in the wounds that have been left open behind, or which have broken down. In certain cholesteatoma cases a persistent fistula is sometimes intentionally formed so as to better treat the middle ear cavity.

OPERATIONS UPON THE LABYRINTH

Recent advances in knowledge of the suppurative diseases of the inner ear or labyrinth make it essential that those who are called upon to do mastoid surgery should have at least rudimentary knowledge of the subject.

It is impossible in this article to discuss even briefly the pathology and the symptomatology of suppurative labyrinthitis secondary to middle ear disease. The author must reluctantly confine himself to a brief description of the tests of the internal ear function, the indications for operation upon the labyrinth and a rehearsal of the different types of operation upon this structure.

The inner ear or labyrinth is composed of 2 parts, the cochlea, and the vestibule and semicircular canals. The cochlea is the organ of the sense of hearing, and the vestibule and semicircular canals have to do with the sense of orientation.

Functional Tests of Inner Ear.—ABSOLUTE HEARING TEST.—The function of the cochlea may be ascertained by the absolute hearing test. The principle of this test is that if any hearing is present in the diseased ear, the cochlea has not been seriously affected by the purulent inflammation. The hearing of the sound ear must be excluded by the use of a noise apparatus (Barany). This is a clockwork apparatus, and when wound, started and placed in the sound ear, makes so much noise as to entirely exclude it from the test. The diseased ear is then tested by the loud voice close to the ear. If any hearing remains, the cochlea has not been invaded by the purulent inflammation. If no hearing remains, the cochlea is not functionating and probably at some time has been invaded by a suppurative process. It is not justifiable, by this test *alone* without the aid of other symptoms, to assume that the cochlea is, at the time of the test, the seat of the suppurative process.

The function of the semicircular canals is best ascertained by (1) the caloric test; (2) the rotation test. Of these the caloric is the most valuable and the easiest to apply.

CALORIC TEST.—This test depends on the fact that, if a normal ear be syringed or irrigated with a solution whose temperature is 86° to 65° F., a *nystagmus* to the opposite side will be *induced.* The *length of time* between the beginning of the test and the onset of the nystagmus is to be noted, as well as the duration of the nystagmus. There are great variations within normal limits. If water of 86° F. be used, the time of irrigation required to produce the nystagmus is about 40 seconds. The physiological limits are from 10 seconds to 3 minutes. The nystagmus has an average duration of about 2 minutes.

If nystagmus cannot be induced, we can state that the normal reaction of the semicircular canals is absent, and, as a rule, in the presence of suppuration of the middle ear, we are justified in assuming an invasion of the vestibule and semicircular canals.

THE ROTATION TEST.—This is less valuable than the caloric test. It is more elaborate, requiring a special revolving chair, and is subject to greater variations and to more sources of error.

It depends on the fact that if a normal person seated with head erect in a revolving chair is rapidly rotated 10 times and then suddenly stopped, an after-nystagmus will be induced whose direction is opposite to the direction of the rotation. The duration of this nystagmus is about 40 seconds. The duration of nystagmus caused by rotation in opposite directions usually varies not more than 3 or 4 seconds. It is the shortening of the duration of the nystagmus of one side, in comparison to that of the other side, that is significant of vestibular destruction. Kerrison states this in the following formula: "Great shortening of the after-nystagmus in one direction, as compared with that in the opposite direction, points to a non-functionating labyrinth on the side toward which the shortened nystagmus is directed."

FISTULA TEST.—In this test a nystagmus is produced by a rarefaction or condensation of air in the middle ear. If present, it is indicative of a fistula of the bony capsule of the vestibule or semicircular canals and of the reaction of these structures. A positive fistula test is of value. A negative test is of no value whatever. Even though there be a fistula, this test cannot be obtained in the presence of a non-reaching labyrinth or in the presence of anything that interferes with the rarefaction or condensation of air in the middle ear.

This test is best performed with a Siegle's otoscope, to which a Politzer's bag has been attached.

Symptoms of Vestibular Irritation.—The characteristic and essential symptoms of vestibular irritation are: (1) nystagmus; (2) vertigo; (3) ataxia.

NYSTAGMUS.—Vestibular nystagmus is a rhythmic movement of both eyes in response to vestibular stimulation. Nystagmus of vestibular origin has the following characteristics: It is composed of a quick movement in one direction followed by a slow recovery. It is named according to the direction of the quick component. It is increased in intensity when the eyes are turned in the direction of the quick component and decreased when turned in the opposite direction.

VERTIGO.—In vertigo of vestibular origin, the patient has the sensation of objects rotating around him. The plane of rotation is always the plane of the nystagmus. The direction of the rotation varies, usually from the side of the slow nystagmus movement. If the patient's eyes are turned in the direction of the quick component, the vertigo is increased.

ATAXIA.—In ataxia of vestibular origin, the patient tends to fall toward the *diseased ear*. Change in position of the head modifies the direction to which the patient tends to fall (i. e. by changing the position of the diseased ear).

Barany of Vienna was the first person to discover the relationship between these three symptoms of vestibular disease, and has thus tersely expressed it:

> "1. Spontaneous vertigo of vestibular origin is always accompanied by some degree of spontaneous vestibular nystagmus, and is always increased when the eyes are turned in the direction of the quick nystagmic movement.
>
> "2. Vestibular ataxia is always accompanied by vestibular nystagmus and is always influenced by the position of the head.

"3. A person exhibiting vestibular nystagmus tends to move (rotate) within the plane of the nystagmus, and to fall in the direction opposite to the direction of the quick nystagmic movement."

General Considerations.—The operation of opening the labyrinth is a dangerous one and the problem of the surgeon is to balance the risk of operation against the ultimate outcome of the labyrinthine inflammation if not operated upon. Inflammation of the labyrinth *per se* is never fatal, but in its tendency to spread to the meninges lies the element of danger.

The aim of operative procedures is thorough drainage of the affected area.

Indications for Operation upon the Labyrinth (Cochlea, Vestibule, and Semicircular canal).—1. In acute diffuse suppurative labyrinthitis, where there are symptoms of beginning involvement of the meninges.

2. In acute diffuse suppurative labyrinthitis which immediately follows a radical operation, probably indicating an injury to the stapes and foramen ovale during operation. These cases, if not operated upon, rapidly incite a meningitis. If these cases are operated upon before meningitis appears, the prognosis is fair. If operated upon after the onset of meningitis, the outcome is usually fatal.

3. In chronic diffuse suppurative labyrinthitis, complicating a chronic suppurative condition of the ear and mastoid process requiring operation.

In these cases the diagnosis of chronic diffuse labyrinthitis is made by the history of one or more attacks of nystagmus, vertigo, ataxia, and upon examination, finding the labyrinth unresponsive to the caloric test and totally deaf. In these cases, if the mastoid is operated upon, the labyrinth must be drained also. However, in this connection, it is possible to conceive of a labyrinth giving this history and these tests and yet so obliterated by fibrous tissue as to be *no* menace if not operated upon.

Here is seen the reason why the labyrinth should be tested in every case requiring a radical operation. In addition to the above, certain conditions occasionally found at operation constitute indications for opening the labyrinth:

1. An open foramen ovale, through which pus is seen to come.

2. A fistula on the promontory or margins of the foramen ovale, from which pus is seen to come.

These cases are probably cases of chronic diffuse labyrinthitis, and it would be unsafe to allow the labyrinth to remain undrained except for the fistulous openings.

In cases of fistula of the external semicircular canal, the labyrinth should not be opened unless the suppurative process has been proven to have invaded the entire labyrinth.

Contra-indications to the Labyrinth Operation.—All cases of acute labyrinthitis not exhibiting symptoms of meningeal invasion and not following immediately after a radical operation.

Surgical Anatomy of the Labyrinth.—THE VESTIBULE.—The vestibule is an oval cavity, about 6 mm. in anteroposterior diameter and about 4 mm. in its vertical and horizontal diameter. It is situated directly internal to the middle ear cavity, and separated from it by the foramen ovale and stapes. The foramen ovale opens into the center of the outer wall of the vestibule. The facial nerve runs just above the foramen ovale and is in relation to the outer wall of the vestibule. Anteriorly the vestibule communicates with, and is in relation to the cochlea; anteriorly it is also in relation to the internal auditory meatus. Internally it is separated from the internal auditory meatus by a thin wall of bone. Inferiorly it is in relation to the jugular bulb.

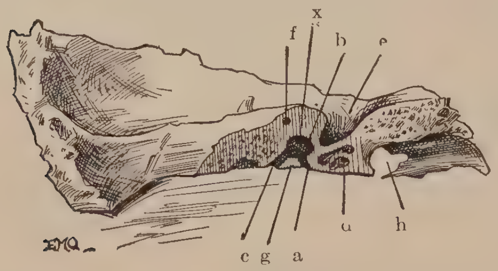

Fig. 18.—A Horizontal Section of Petrous Portion of Temporal Bone, Through Upper Part of Oval Window. Showing the relation of the vsetibule, semicircular canals, cochlea and internal auditory meatus. A vertical section (Fig. 19) has already been made from this specimen. a, Foramen ovale; b, vestibule; c, external semicircular canal; d, cochlea; e, internal auditory meatus; f, posterior semicircular canal; g, facial canal; h, carotid canal; x, opening of semicircular canal into vestibule; b, section of posterior semicircular canal. (From a preparation by E. B. Burchell.)

THE COCHLEA.—This is a bony tube coiled on itself around a central stem, the modiolus. Its central axis is horizontal and is directed outward and forward. Internally its base is in relation to the internal auditory meatus; externally its apex is in relation to the promontory of the middle ear. Antero-inferiorly it is in relation to the carotid artery, inferiorly to the jugular bulb and posteriorly to the vestibule.

The modiolus or bony stem contains minute channels for the cochlea nerve, and if the modiolus is injured during operation, these afford direct communication with the subarachnoid spaces through which infective material may pass, setting up a leptomeningitis.

THE SEMICIRCULAR CANALS.—These are semicircular bony canals 1 mm. in diameter. They are 3 in number and lie at right angles to each other, communicating with the vestibule by 5 openings. From their position they are named: (1) The horizontal or external; (2) the anterior (or superior) vertical; (3) the posterior vertical.

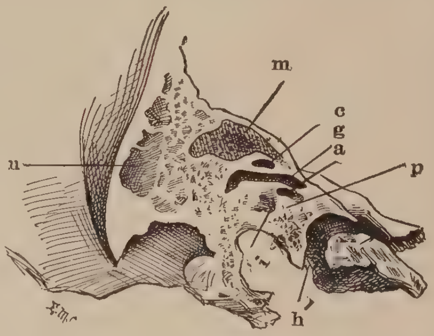

Fig. 19.—A Vertical Section Through Long Axis of Petrous Portion of Temporal Bone. a, Foramen ovale; c, external semicircular canal; g, facial canal; h, carotid canal; i, foramen rotundum; m, antrum; n, mastoid cells; p, promontory. (From a preparation by E. B. Burchell.)

Each canal at its anterior end expands into an ampulla about 2 mm. in diameter. The posterior end of the anterior vertical and the upper end of the posterior vertical canals unite to form a common opening into the vestibule.

Of these the horizontal is the most important surgically. It forms a guide to the antrum and facial nerve, its ampulla a guide to the vestibule. It is the one most frequently seen, and is most commonly attacked by the erosive inflammations in the middle ear and mastoid. With the head erect, its position is very nearly horizontal.

Surgical Guides to the Vestibule.—The aim of all operative procedures upon the labyrinth is to make a free opening into the vestibule. The guides to the vestibule are:

1. The anterior ampullar end of the horizontal semicircular canal. The vestibule lies below and behind it.
2. The posterior end of the horizontal canal.
3. The foramen ovale.
4. The angle of intersection of the planes of the semicircular canals.
5. In the Neumann operation, the line of intersection of the planes of the posterior vertical and the horizontal canals.

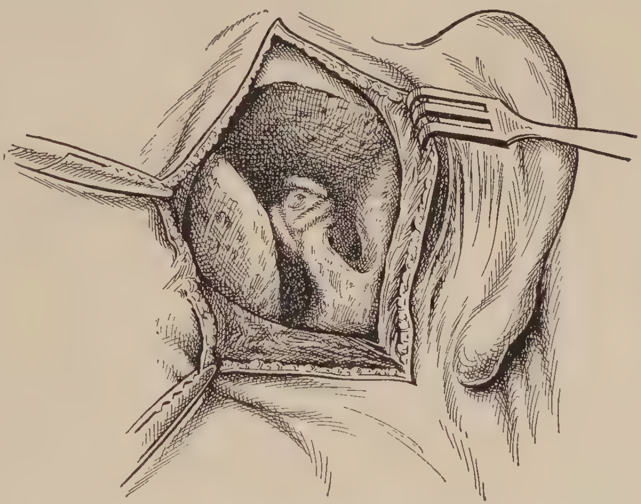

Fig. 20.—A Radical Mastoid Operation Has Been Performed in a Highly Developed Pneumatic Bone. The relative position of the semicircular canals is well seen. Below them is seen the fascial ridge. (From a dissection for the author by Dr. R. T. Atkins.)

In any case it is assumed that the labyrinth operation has been preceded by an extremely thorough radical operation. In this operation the anterior lip of the eustachian tube must be obliterated as thoroughly as possible, the facial ridge removed so as to get a good exposure of the foramen ovale, and the angle between the dural and sinus plates, posteriorly, thoroughly exenterated.

Hinsberg Operation.—1. The stapes is extracted with forceps.

2. The bridge of bone between the round and oval windows is removed with a small gouge. With a small curet this opening is further enlarged downward and forward.

3. A small probe, bent at right angles a short distance from its extremity, is inserted into the above opening and the position of the roof of the vestibule ascertained.

4. The external semicircular canal must now be opened at its anterior

half. This is done with a small keen chisel, taking away the bone in thin layers. The position of the facial nerve immediately beneath the canal and above the oval window must be remembered. Any rough or clumsy work at this step of the operation will fracture the Fallopian canal and endanger the integrity of the nerve. After the ampulla is exposed, its relation to the roof of the vestibule is noted by means of the probe and the roof of the vestibule entered by means of a small gouge or curet, caution being taken again to avoid injury to the facial nerve. The opening into the vestibule may be enlarged backward as far as is necessary. The cochlea is now further opened by the removal of the promontory with a small gouge.

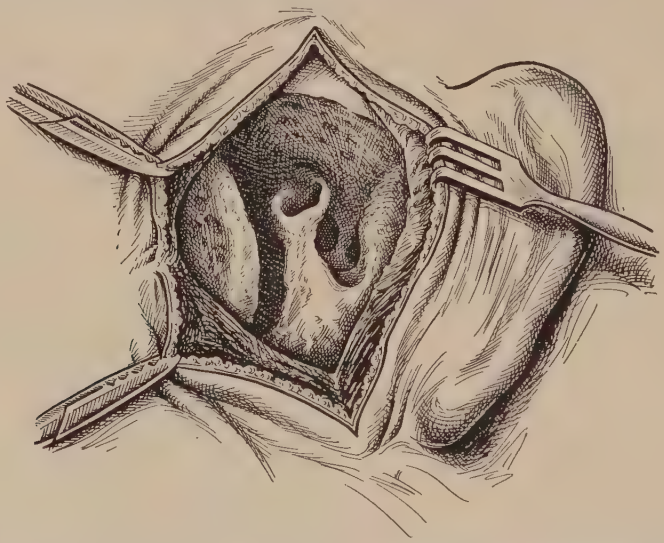

Fig. 21.—Hinsberg Operation Completed. In the central part of the figure the opening into the vestibule is seen. Slightly below and in front of this is seen the opening formed by the removal of the partition between the oval and round windows. (From an original dissection.)

Neumann's Operation.—In this operation the vestibule is approached from behind through the posterior fossa. The sinus is uncovered posteriorly (see Sinus Thrombosis) below the knee, and the dura in front of it and over the tegmen antri, exposing a space bounded by the posterior part of the petrous pyramid in front and the dural plate above and the sinus posteriorly.

The dura is now cautiously separated from the posterior surface of the pyramid, care being taken to avoid wounding the superior petrosal sinus above and the jugular bulb below. This separation continues inward until almost the margin of the internal auditory meatus is reached. The dura is now protected and held away from the posterior surface of the pyramid by the bowl of a large curet, and the edge of the pyramid removed in thin layers. This is done cautiously with a sharp chisel or gouge, and the exposed surface constantly scrutinized for a dark opening (the lumen of the posterior canal). This is noted and the bone further removed, which will expose 2 openings, the cross sections of the same canal. Still further removal of the bone will disclose a third opening, the lumen of the posterior half of the horizontal canal. A triangular space inclosed between imaginary lines joining these 3 openings forms the guide to the vestibule. By removing the bone in this area an opening is made into the posterior part of that cavity. The bone is now removed between the oval and round windows, and the promontory removed, exposing the first and second turns of the cochlea.

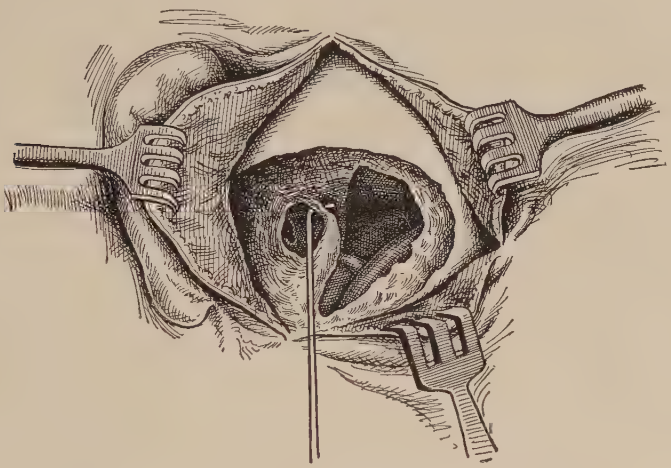

FIG. 22.—NEUMANN'S OPERATION. This dissection shows the completed operation. A probe has been passed through the united oval and round windows, under the bridge of bone containing the facial nerve; its end lies in the cavity of the opened vestibule. Behind is seen the lateral sinus and the dura of the middle and posterior cranial fossæ. (From a dissection by the author.)

Structures to Be Avoided in the Labyrinth Operation.—1. THE MODIOLUS.—Any injury to the modiolus, caused by curettage of the cochleal cavity or ill-advised attempts at its removal, opens up a direct communication with the subarachnoid spaces of the brain, and is extremely liable to set up a purulent meningitis.

2. INTERNAL AUDITORY MEATUS.—The dura around the meatus is closely adherent to the bone and the injudicious use of a chisel in this region is apt to open into the subdural space.

3. JUGULAR BULB. 4. CAROTID ARTERY.—The location of these vessels must be borne in mind.

5. FACIAL NERVE.—It is liable to be injured during the operation, unless extreme caution be used.

Choice of Operations.—The Neumann operation is indicated when intracranial complications are suspected. A deep epidural abscess in the posterior surface of the pyramid may be exposed, or in a beginning meningitis the dura in the posterior fossa may be incised. In this operation there is less danger of injuring the facial nerve. The only objection to it is the necessary exposure of the dura with its risk of injury. It is hard to perform in cases where the dura is very low and the sinus far forward. Operations of the Hinsberg type have their indication in the cases where the process is confined to the temporal bone.

After-treatment.—The posterior wound should be left open and separate packing introduced to the wound in the labyrinth. The patient should be kept in bed for at least three weeks following the operation.

SURGICAL TREATMENT OF THROMBOSIS OF THE SIGMOID AND LATERAL SINUS

The aim of surgical measures upon the sigmoid and lateral sinus is the removal of the infected clot and the sequestration of the sinus from the general circulation.

Surgical Anatomy.—SURFACE MARKINGS.—The course of the lateral sinus may be indicated by a line drawn from the external occipital protuberance to the center of the external auditory canal. That part of the sinus below the bend or knee which occurs in the posterior part of the mastoid bone, and which extends from the knee to the jugular bulb, is called the sigmoid sinus. This portion of the sinus has no definite surface landmark, as it may occupy a variable position on the inner surface of the mastoid bone. Beneath the middle ear the sigmoid sinus makes a sharp turn upward, and expands to form the jugular bulb. The knee of the sinus is joined by a smaller vein, the superior petrosal sinus. The mastoid emissary vein joins the sigmoid sinus, carrying the blood from the scalp over the mastoid process. The inferior petrosal sinus joins the jugular bulb beneath the cavity of the middle ear.

The sigmoid and lateral sinus is simply a large vein which runs on the inner surface of the mastoid process, and is covered by a thin process of dura mater. It is separated from the mastoid cells by a plate of bone of ivory-like whiteness and consistency, the so-called *sinus plate.*

Indications for Operation.—Operation is indicated in every case of sinus thrombosis as soon as the diagnosis has been made. It is beyond the scope of this article to consider at length the diagnosis of sinus thrombosis. A typical case, giving the history of a severe chill and a sudden rise in temperature to 104° or 105° F., with an equally sudden fall, when accompanied by a positive blood culture and a negative physical examination, except for the ear and mastoid process, offers no special difficulty in diagnosis. It is in the cases of acute and chronic mastoiditis which accompany the exanthemata or other severe infections, that a positive diagnosis is often difficult. In a case of acute mastoiditis, either before or after operation, the diagnosis of this condition must be made on the history and the above signs (chill, high temperature with so-called "church steeple" rise and fall), either with or without a positive blood culture, rather than on the appearance of a local condition in the mastoid wound. It is in the exclusion in other parts of the body of the causes of chills, high temperature and positive blood culture, that most of the mistakes in the diagnosis of sinus thrombosis are made. The conditions most frequently occurring before or after mastoid operation, which may be mistaken for sinus thrombosis, are:

1. Erysipelas.
2. Pneumonia.
3. Cellulitis of the wound.
4. Septic infection of the kidney.
5. Malaria.

In this connection, it must be remembered that positive blood cultures occur often in scarlet fever. A positive blood culture, other causes being excluded in a case of acute mastoiditis before or after operation, is strong presumptive evidence of a sinus thrombosis. However, we must not rely on this entirely, but place our chief reliance upon the clinical signs. On the other hand, a negative blood culture does not exclude a sinus thrombosis.

The operation for sinus thrombosis consists in a removal of the infected clot and an obliteration of the lumen of the sinus. This may or may not be accompanied by a ligation or a resection of the jugular vein.

General Indications for Ligation and Resection of the Jugular Vein.—At the present time the question of ligation and resection of the jugular vein at the time of operation is an open one. Otologists in this country may be divided into 2 groups: the radical, who believe that in every case of sinus thrombosis the jugular vein should be resected before the sinus is opened; and the conservative, who believe that the sinus should first be inspected and the question of resection decided upon by consideration of the appearance of the sinus itself or by consideration of the history of septic absorption previous to or following operation. The conservative otologists believe that the vein should be resected at the time of operation only when the sinus shows signs of disintegration, or when the patient shows signs of marked septic absorption of some duration. In the ordinary case, when the clot removed from the vein is firm and has not broken down and become purulent, it is removed; and it is customary to wait 24 hours before considering ligation.

My procedure is as follows:

1. Expose sinus.
2. Open sinus.

If the clot is found and it is firm, it is removed. If free bleeding occurs from the jugular end in children, the vein is not ligated. In adults, if the patient is in good condition, the vein is resected. If upon opening the sinus the clot is found to be disintegrated, the sinus is packed temporarily and the vein ligated and resected, the clot being removed after ligation or resection of the vein. If the clot is firm and free bleeding does not occur from the jugular end, I believe that it is safe to wait 24 hours before ligating the vein, if there has been no history of septic absorption. This rule is especially applicable in children, where the shock of ligating and resecting the vein is much greater than in adults, and adds materially to the danger of the operation.

If upon opening the sinus no clot is found and a blood culture is negative, the sinus is packed for 24 hours. If no clot is found and the blood culture is positive, the vein is usually ligated. In general, the positive blood culture in a case of sinus thrombosis is an indication for the ligation of the jugular vein.

Operations upon the Jugular Bulb.—In certain cases of sinus thrombosis in which the clot has been removed and the vein ligated, and in which the symptoms of septic absorption continue, certain otologists advise the so-called "gutter" operation. This has been especially advocated by Grunert.

From personal observation, however, I believe that this operation, which consists in the exposure of the jugular bulb behind the facial nerve down to the jugular foramen, is unnecessarily severe and fails of its purpose.

In those cases which I have observed, it has only hastened the fatal outcome. If, in these cases, the patient is unable to take care of the amount of infected material between the open sinus above and the open jugular vein below, I believe that the shock of this operation, which is very severe, only further lessens the feeble resistance of the patient.

OPERATIVE TECHNIC

Cases of sinus thrombosis operated on by the aural surgeon are all secondary to operations for acute or chronic mastoiditis.

The sinus is never attacked without a preliminary exenteration of the mastoid process. Accordingly, in the following description of the operative technic, it will be assumed that either the simple mastoid or the radical mastoid operation has been performed. If the sinus operation is to be performed at the time of the original mastoid operation, this preliminary operation should be performed as rapidly as is consistent with a fairly thorough exenteration of the process. In previous descriptions of this operation, sufficient emphasis has not been laid upon the importance of a thorough, but rapid operation. In the cases in which mastoid operation has been performed some time previously, the need for rapidity in the operation is not so marked, unless the patient is in a desperate condition. The point which I wish to emphasize, however, is that in the performance of the preliminary mastoid operation, a rapid operation is important for the welfare of the patient.

The usual mastoid operation having been performed, the sinus may be exposed in the following steps:

1. Prolongation of the posterior incision.
2. Preliminary delineation of the sinus plate.
3. Preliminary removal of the bone over the posterior part of the sinus plate.
4. Removal of the thin sinus plate.
5. Placement of iodoform plugs.

6. Opening of sinus and removal of clot.
7. Packing of sinus and the application of the dressing.

1. Prolongation of the Posterior Incision.—The posterior incision is now prolonged directly backward toward the external occipital protuberance. The length of this prolongation is usually from 1 in. to 1½ in. This incision is extended through the periosteum directly to the bone. The periosteum is elevated over this area and the hemorrhage checked.

2. Preliminary Delineation of the Sinus Plate.—The contour of the sinus plate within the limits of the mastoid process is now rapidly outlined by the removal of the cells or cancellous tissue around its boundary. This is conveniently done with a medium-sized Volkmann curet. Cells resting directly upon the sinus plate itself may be rapidly removed by a Richards curet. At the same time some of the bone of the sinus plate itself may be conveniently removed. In working around and directly over the sinus care should be taken that the curet does not plunge through the sinus plate and injure the sinus itself; for the resulting hemorrhage adds greatly to the difficulties of the operation. Anteriorly the sinus plate should be exposed almost down to the jugular bulb.

3. Removal of Bone Over Posterior Part of Sinus Plate.—At the upper and posterior boundaries of the mastoid process the bone will be found to be of a denser consistency and less cellular in structure. This bone must be removed from over the course of the sinus plate before the plate can be conveniently attacked. This bone is removed along the line of the sinus (extending backward toward the external occipital protuberance) either with a broad chisel or with the Richards curet, according to its hardness or density. This excavated area should be gutter-shaped with its boundaries extending somewhat beyond the boundaries of the sinus. This procedure thins the bone over the sinus so that it may be conveniently removed with the rongeur forceps.

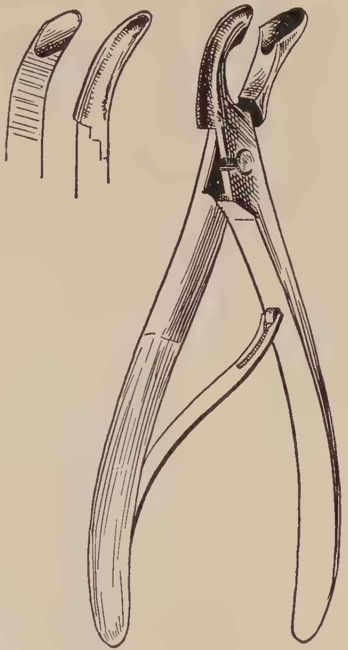
FIG. 23.—BAYNE'S RONGEUR FORCEPS.

4. Removal of the Sinus Plate.—The best instrument for the removal of the bone of the sinus plate is a rongeur. This rongeur must have certain characteristics. It must be powerful and sharp to enable the bone to be bitten away cleanly without injury to the sinus itself. Its blade must have a certain convexity so that when it is introduced beneath the sinus plate the convexity of the blade will push away the sinus from the bone. The blade should be bent almost at right angles a short distance from its extremity to enable the rongeur to be easily and conveniently applied to the sinus plate. I believe these qualities to be embodied in a rongeur of the Bayne pattern. A powerful forceps that may also be used is the Brandegee rongeur. This last instrument is a straight rongeur and at times is awkward to use.

Before the forceps can be used a small portion of the sinus must be exposed in the following manner: If at the time of operation a sufficient area of the sinus has been found to have been exposed by the pathological process, advantage is taken of this and the remainder of the plate removed with the rongeur. If the sinus is found intact, the following procedure is adopted: A small area of sinus plate, about 1/4 in. in diameter, is cautiously curetted away with the Richards curet until the sinus is exposed. This is preferably done just below the knee. A small curet is then gently inserted beneath the bone and the thin plate pried away until the area is enlarged sufficiently to admit the blade of the rongeur forceps. A small probe or grooved director is now inserted underneath the plate in order to be sure that the sinus is not adherent to the bone that is to be removed. The rongeur forceps (Bayne) are now inserted into the opening, one blade being between the sinus and bone, the other blade being over the sinus plate. They are now withdrawn slightly in order to be sure that no sinus is included between their grasp and cut squarely through the bone. This process is repeated until the sinus plate has been removed from near the jugular bulb below to the desired point posteriorly. It is extremely important before using the forceps to be absolutely sure that the bone and the sinus plate are not adherent, and this can only be ascertained by the careful use of a probe or director. If the bone is found to be adherent, it must be carefully separated from the sinus before it is removed. In cutting the bone care must be taken to lift the point of the instrument slightly away from the sinus in order that it will not dig into and injure that structure. In this manner the sinus plate is carefully removed from the top and sides of the sinus over the area desired by the operator. Enough of the sinus plate should be removed so that when the iodoform plugs are in position a space of 1 in. to 1½ in. will be left between them.

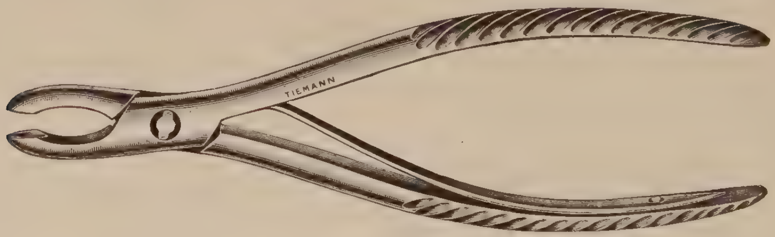

Fig. 24.—Brandegee's Rongeur Forceps.

5. Placement of Iodoform Plugs.—At this point in the operation it would be well for the operator to inspect the uncovered sinus, for although the condition of the interior of the sinus cannot be judged by the appearance of its exterior, nevertheless at times some information may be obtained. In the neglected cases the sinus may seem to be collapsed and pus may be seen to issue from a perforation in its wall. In the majority of cases the sinus wall will be found to be dull and lusterless, or else covered with granulations. This appearance is in contrast to the healthy sinus exposed at the posterior part of the operative cavity. The determination of a clot within the sinus by palpation of the unopened sinus is extremely uncertain. Aspiration with a hollow needle is useless. The only way of determining definitely the presence of a clot within the sinus is by opening its lumen with a knife or scissors and inspecting its interior.

Hemorrhage from the sinus is best controlled by plugs of iodoform gauze. These plugs are made by rolling or folding iodoform gauze into approximately the shape of a lead pencil and cutting them in lengths of about 3/8 in. The operating nurse should always have a supply of these on hand. Two of these plugs are taken and held with forceps by the first assistant against each extremity of the exposed sinus, and are so placed that gentle pressure in that locality will effectually check the flow from that end of the sinus. The proper manipulation of these plugs is a very essential step at this stage of the operation. With the assistant alert to make pressure on either end of the sinus at the word of the operator, the sinus is now quickly opened with a knife the entire length of its exposure. From the manner of the hemorrhage certain deductions may be made.

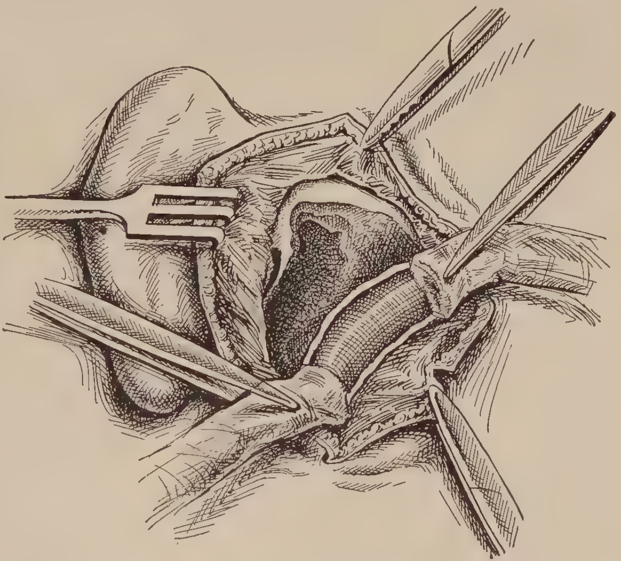

Fig. 25.—Exposure of the Lateral Sinus. The lateral sinus is shown uncovered and the iodoform plugs held in place preliminary to its incision. (In this drawing the plugs are longer than those used in actual practice.)

6. Opening of the Sinus.—1. SINUS OPENED, NO HEMORRHAGE.—This indicates the presence of a firm clot in the interior of the sinus. This may be further verified by holding apart the edges of the incision with the forceps and inspecting its interior.

2. SINUS OPENED, FREE HEMORRHAGE.—Usually when the sinus is opened there is a free hemorrhage, and it is necessary for the operator to determine, if possible, its source. Accordingly after a moment's waiting pressure should be made on the jugular end. If the hemorrhage stops, this shows

that the torcular end is obstructed by a clot. If the bleeding continues slightly, it comes in all probability from either the mastoid emissary vein (the superior petrosal sinus) or else a partially obstructed torcular end. Pressure should now be made with the plug at the torcular end of the sinus and the plug lifted from the jugular end. If there is no hemorrhage, this indicates that there is an obstructing clot in the jugular end of the sinus. A small amount of hemorrhage from this end probably indicates a partial clot in this locality. Free bleeding from the jugular end does not rule out a clot in this locality, for the hemorrhage may come from the inferior petrosal sinus. If a clot is found in the torcular end and if it cannot be dislodged by the gentle use of a dull curet, the sinus should be further exposed and opened until **the end of the clot is reached and free bleeding ensues.** If a firm clot is found at the jugular end, it is safer to stop immediate operation upon the sinus and ligate or excise the jugular vein, returning later to the sinus. If, however, a firm clot is expelled from the jugular end and free bleeding ensues, and the patient has given no history of septic absorption, I believe that it is sometimes safe to wait 24 hours before ligating or excising the jugular vein. The clot, in all cases, is most conveniently removed from the lumen of the sinus with a dull curet. If the clot has been removed, fresh iodoform plugs should be adjusted to each end of the sinus.

7. **Packing of the Sinus and Application of the Dressing.**—The edges of the open sinus should be trimmed away with a pair of curved scissors, and the remainder of its lumen packed with iodoform gauze. The mastoid wound is then firmly packed in the usual manner. In making pressure on the sinus at the time of operation and after operation has been completed, the operator should remember that he is packing directly against the brain and should use no more pressure than is actually necessary for the stopping of the hemorrhage. The plugs and packing in the sinus should be left in situ for 5 days. They should then be cautiously removed, and if bleeding recurs from the sinus, they should be replaced and left for another 3 or 4 days. The remainder of the mastoid wound, with the exception of the sinus packing, should be treated as in an ordinary mastoid operation. In opening the sinus it is best to keep the patient in bed for at least 14 days after operation.

LIGATION AND RESECTION OF THE INTERNAL JUGULAR VEIN

The question of resection of the jugular vein has been alluded to. Under this heading I wish to give in more detail the indications and the technic of the operation.

Indications.—1. In every case of sinus thrombosis in which there has been a history of marked septic absorption or metastatic abscess.

2. In cases of sinus thrombosis in which the sinus has been opened and in which the symptoms of septic absorption continue.

3. In cases of sinus thrombosis in which the sinus has been opened and

in which a disintegrated clot is found at time of operation, although no symptoms of sepsis have appeared.

Contra-indications.—1. In cases of sinus thrombosis in which the sinus has been opened and in which further operative interference would probably be fatal to the patient. In these cases it would probably be better to wait 24 hours before resection of the vein.

2. In small children and infants in whom resection of the vein would be a grave surgical procedure.

The question of resection of the jugular vein depends not only upon the patient's condition, but upon the technic and the experience of the operator. If he be one of sufficient experience, he can quickly resect the vein without the shock and trauma that would be caused by a less experienced operator. This must always be taken into consideration. There is no doubt but that the system can take care of large quantities of infecting micro-organisms introduced into the blood, and it is now generally conceded that a moderate delay in the resection of the vein is not fraught with the danger formerly supposed. By this I do not wish to be understood as advocating delay in every case, but at times I believe that it is finer judgment to wait than to balance the resisting powers of the patient against the shock of an immediate operation.

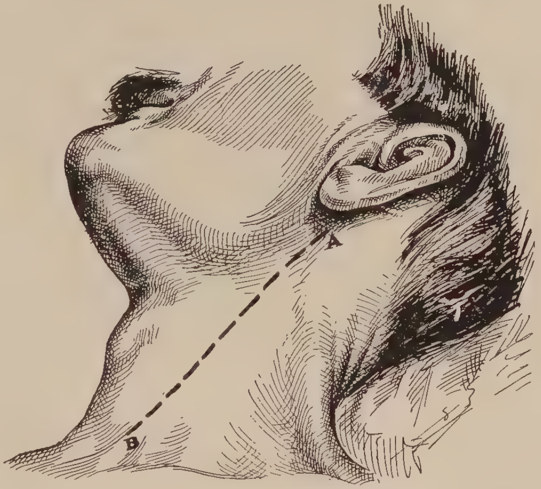

Fig. 26.—Ligation and Excision of Internal Jugular Vein (1). Line of incision.

Operative Technic for Ligation and Resection of the Internal Jugular Vein.—For the instruments necessary, see page 105.

If the operation is performed subsequent to the mastoid operation, the instruments should be resterilized; and the towels around the patient, and the gowns and gloves of the operator and his assistants should be changed. It is assumed that the side of the neck of the patient has been previously prepared in the manner described. A sandbag should now be placed under the patient's shoulders and the head of the patient turned toward the opposite shoulder.

The incision should now be made along the line of the sternomastoid muscle (from A to B, Fig. 26), from the clavicle below to within ½ in. of the mastoid incision above. This incision should be carried through skin, subcutaneous tissue and the platysma myoides muscle. In making this the external jugular vein is encountered and should be divided between clamps or ligatures. A search should now be made for the anterior border of the sternomastoid muscle. This is recognized by the fact that its fibers run up and down. It is covered by a layer of the deep cervical fascia. The anterior surface of this should be slightly separated, and the common sheath of the carotid artery, jugular vein and pneumogastric vein will be found to be exposed. This is also covered by a process of deep cervical fascia.

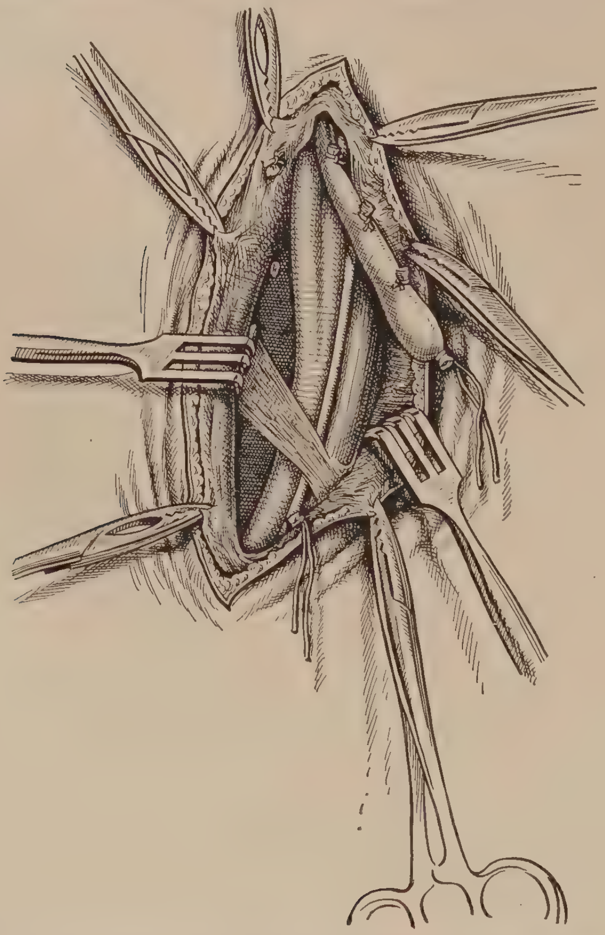

Fig. 27.—Ligation and Excision of Internal Jugular Vein (2). The operation is almost completed. The vein is seen ligated and cut below. The stump of the vein is seen in the lower part of the incision. At the upper and left hand part of the incision is seen the ligated stump of the facial vein. Internal to the vein is the carotid artery, starting to bifurcate, and the pneumogastric nerve. The omohyoid muscle is seen crossing these structures posteriorly, the sternomastoid muscle is held back by a retractor. (From a dissection for the author by Dr. R. T. Atkins.)

The jugular vein lies to the outer side of the carotid artery, and will be recognized as a bluish mass alternately emptying and filling with the movements of the respiration. The sheath must now be opened. This is best done in the neighborhood of the omohyoid muscle. The first assistant should hold up the sheath with a pair of forceps, while the operator holds the other side, taking care to lift the sheath away from the vein. A small opening is now made into the sheath with the scissors, taking care not to cut the vein. The structure of the vein will be found to be exposed immediately beneath this opening. With the scissors pushed through this opening, the vein is now separated from the sheath from below upward, and the sheath opened. This process should be repeated until the sheath of the vein has been opened from the omohyoid below to above the entrance of the facial vein. The vein is now separated by blunt dissection from the posterior part of the sheath, care being taken not to injure the pneumogastric nerve which may be seen running posteriorly between the artery and the vein. The large branches entering the vein should be tied between two ligatures and divided. These are usually the middle and superior thyroid veins, the lingual and facial veins, and occasionally a branch from the external jugular. If any large lymphatic glands are found overlying the vein, they may be removed, provided it may be accomplished without much effort. However, I believe it to be unwise and unnecessary to attempt an elaborate dissection of the glands at this time. After the vein has been separated throughout the entire length which is to be removed, it may be doubly ligated below and the vein cut between ligatures. The remaining main branches are now quickly doubly ligated and divided. The main trunk of the vein is now pulled down from its insertion in the upper part of the wound and ligated as high as possible. It is then cut below the ligature. If blood is wished for a culture, the main trunk of the vein is allowed to fill with blood and is doubly ligated at the upper part before being divided. Further bleeding points are clamped and ligated, and the cavity flushed with normal saline. The wound is then partially sutured and cigarette drains inserted, first, to the stump of the vein above; and second, to the lower angle of the wound below. The ligatures on the main trunk above should be of No. 2 plain catgut. The resulting scar will be less if the platysma and deep fascia are sutured in a separate layer. This should be done with interrupted sutures of No. 1 plain catgut. The skin is best sutured with interrupted sutures of silk or silkworm-gut.

The jugular dressing is now applied in the form of a double figure 8, passing below and under both axillæ. Care should be taken, especially in children, to see that chafing is avoided by placing plenty of cotton in these localities. If there is considerable oozing, the outer dressing may be changed on the first day after operation. Ordinarily, the first dressing is done on the third or fourth day after operation and afterward every day if deemed necessary. Rarely, if ever, can we get the jugular wound to heal by primary union. The reasons for this are as follows: first, infection from the mastoid wound and from the upper end of the jugular vein; second, lowered resistance of the tissues due to excessive blunt dissection in removal of the vein.

OPERATIONS FOR BRAIN ABSCESS OF OTITIC ORIGIN

Brain abscesses occurring as a complication of aural inflammation are mainly of two types, cerebral and cerebellar. The cerebral abscesses are the most numerous and occur in about 80 per cent. of the cases.

CEREBRAL ABSCESS

Surgical Anatomy.—A vast majority of the cerebral abscesses occur in that part of the temporosphenoidal lobe which lies just above the middle ear and antrum, and separated from them by an extremely thin plate of bone, the tegmen tympani et antri. Occasionally an abscess of otitic origin occurs in the frontal lobe. The descending horn of the lateral ventricle lies in the posterior part of the temporosphenoidal lobe, but is usually not injured in the attempts to locate an abscess in this locality.

Indications for Operations.—As the only acknowledged treatment of brain abscess is surgical, the indications for operation are obvious. It should be the aim of the surgeon to discover and evacuate the abscess with as little disturbance and manipulation to the surrounding healthy brain tissue as is possible. If the abscess has been discovered and evacuated, and if a suppurative leptomeningitis does not already exist at the time of operation, the ultimate recovery of the patient depends largely upon how scrupulously the surgeon has followed this operative axiom.

If the operation is secondary to a simple or radical mastoid, this cavity should be gently curetted of granulations, flushed with saline and temporarily packed with iodoform gauze. If the operation for brain abscess is performed at the time of the operation for the causal ear condition, the preliminary operation should be performed as rapidly as possible, a simple mastoid for brain abscess following an acute mastoiditis, and a radical operation for a brain abscess following a chronic or an acute exacerbation of a chronic inflammation of the middle ear and mastoid cells.

Preparation of the Patient.—The usual preparation for the mastoid operation should be extended so as to include one-half the skull of the side to be operated upon (see page 103). If, for obvious reasons, the preparation occurs immediately after the mastoid operation, this area is closely covered by a piece of sterile gauze, the half of the scalp *dry* shaved and tincture of iodin applied. The operative field is inclosed in sterile towels and fresh iodin is applied to the edges of the mastoid wound. All instruments should be resterilized, and the operator and his assistants should don fresh gloves and gowns.

Technic of Operation

The operation can be conveniently described in the following steps:

1. Incision and reflection of flaps.
2. Removal of tegmen tympani and tegmen antri, with a portion of the *squama*.
3. Exploration of the dura covering tegmen tympani et antri.
4. Exploration of temporosphenoidal lobe.
5. Insertion of drains.
6. Dressing.

1. Incision.—From the upper end of the usual mastoid incision, an incision is made directly upward for a distance of 1½ in. (4 cm.). The mastoid incision is also prolonged directly forward for ¾ to 1½ in. (2 to 4 cm.). These incisions are carried directly to the bone and the flaps thus formed rapidly reflected. The temporal artery is severed and should be quickly clamped and tied. Some authors prefer a large horse shoe incision starting from the upper part of the mastoid incision; but the above incisions give adequate exposure and do not expose as large an area to subsequent infection.

2. **Removal of the Bone.**—With a large rongeur the tegmen antri and tegmen tympani are now removed, together with a portion of the squama. The area of bone removed in the squama should be enough to explore adequately the temporosphenoidal lobe, provided a fistula is not found in the dura of the tegmen. It should be oval and of the dimensions 2 by 2½ in. (5 by 6.5 cm.). The accompanying diagram gives a clear idea of its extent and location (Fig. 28). If the squamous portion is unusually thick, the chisel may be required to thin the bone sufficiently to enable the rongeur to be used.

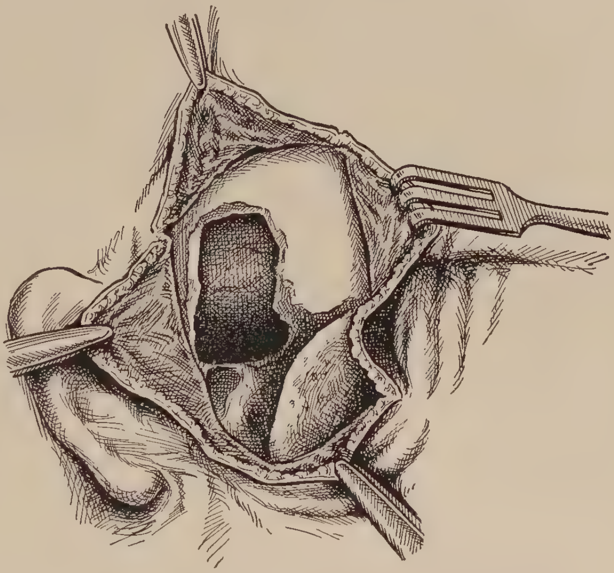

FIG. 28.—CEREBRAL ABSCESS. This illustration shows the area of dural exposure, necessary for an exploration for a temporosphenoidal abscess. Some surgeons, however, prefer to expose the dura more posteriorly than the above figure indicates. (From a dissection for the author by Dr. R. T. Atkins.)

3. **Examination of the Dura.**—The dura covering the tegmines tympani et antri should now be carefully scrutinized and examined with the probe for any fistulous openings leading to an abscess cavity within the temporosphenoidal lobe. If one is present, it is of vital importance to find it. The fistulous opening is usually small and its orifice often obscured by the surrounding granulations. Pus is often found issuing from its lumen. During this examination, care should be taken not to injure the granulations on the dura. *On no account* should they be curetted. They are nature's barriers to the spread of the infection, and curettage of dural granulations serves no useful purpose and may convert a localized meningitis into a general one.

If a fistulous opening be found, a cotton-wound applicator may be gently passed into the abscess cavity to aid drainage, and then withdrawn. Further operative procedure should be omitted, the wound packed with iodoform gauze and a dressing applied. The wound should be dressed daily and further operative procedure upon the fistula leading to the brain abscess should depend upon the recurrence of the symptoms of increased *intracranial tension.* The majority of cases will drain without further interference.

This treatment is advocated by Kerrison and Dean and meets with my hearty approval. If a wider opening is subsequently found necessary, a blunt-pointed bistoury should be inserted into the fistula and the tissues incised in a direction directly outward. In doing this, an attempt should be made not to pass beyond the adhesive inflammatory zone surrounding the fistula. If the insertion of a drain into the fistula is deemed necessary, a strip of gauze or a small cigarette drain may be used. It has been my observation that when these drains are removed at the daily dressing, pus wells out from the abscess cavity with considerable volume, and it has seemed that instead of fulfilling their purpose, they have slightly hindered drainage. I believe that it is better to omit the insertion of drains into these fistulæ and insure the desired result by the daily gentle passage of a cotton-tipped probe into the abscess cavity. If, after careful search of the dura covering the tegmen, no fistula is found, I follow the teaching of Macewen, postponing further exploration, and pack this area for 24 to 48 hours, providing the general symptoms permit. This allows adhesions to form between the coverings of the brain, and when this area is finally explored, there is less danger of disseminating infectious material through the pial and arachnoid spaces.

At this time I believe in doing a classical subtemporal decompression operation in the usual sterile field above and in front of the one just packed. This relieves intracranial tension still further and allows the surgeon to wait longer for localizing symptoms to appear.

If the general symptoms permit of no delay, the temporosphenoidal lobe is exposed through the dura in the following manner:

4. Exploration of the Temporosphenoidal Lobe.—The most suitable instrument for this purpose is a straight, pointed bistoury with a rounded end. At this point the surface of the dura should be rendered as sterile as possible by mopping with peroxid and flushing with a warm saline solution.

The brain knife should be plunged directly inward just above the external auditory canal. After it has been passed into the brain substance for 5 mm. ¼ in.), the surgeon should pause and gently press the knife to one side to see if any pus escapes. If no pus is found, the process is repeated every quarter of an inch until a depth of 1½ in. (4 cm.) is reached. If pus is not found, a similar exploration should be made ⅜ in. (6 mm.) behind and in front of the original puncture. If pus is not found in this area, the advisability of making further incisions above, in front and behind this area must be considered. While superfluous punctures through the dura are to be avoided if possible, they are not in themselves especially dangerous if carefully done under aseptic precautions, and the possibility of leaving brain abscess undiscovered must be taken into consideration.

As a rule, the depth to which an exploratory incision may be carried is 1½ in. (4 cm.). In exceptional instances abscesses have been reached at a greater depth.

If pus escapes at any time, the knife should be held in that position until the pus ceases to flow and until a cigarette drain is inserted into the abscess cavity. If the abscess cavity appears to be a large one, the brain tissue should be incised to a width of ½ in. to allow of free drainage.

THE WHITING ENCEPHALOSCOPE.—This instrument is at times useful in facilitating drainage of an abscess cavity. I, however, reserve its use for those cases where drainage by the above simple methods is ineffective and where there are symptoms of the formation of a secondary abscess. It should be used with extreme care and gentleness. It is inserted into the fistula or incision for ¼ in. (7 mm.), and its obturator removed. Any pus appearing in its lumen is sponged away with cotton-tipped applicators and the general direction of the fistula observed by pushing the instrument, so that the meniscus of its collapsed boundaries is in the center of the field of the instrument. The obturator is reintroduced from time to time when necessary to facilitate its inward movement. We know when the abscess cavity is reached by the sudden outpouring of pus and by the fact that gentle rotation of the instrument no longer discloses a meniscus, but the smooth walls of the abscess cavity. The inexperienced surgeon could easily create a false passage or carry pus from the abscess into the surrounding healthy tissue. A good headlight is necessary.

5. **Drainage of the Abscess.**—A rubber or glass tube gives the best drainage, but on account of the extreme liability of secondary hemorrhage following its use, aural surgeons are generally united in the use of gauze or cigarette drains (gauze and rubber tissue).

I use a cigarette drain, and when the abscess cavity grows very small, a simple strip of rubber tissue. It should be inserted well into the abscess cavity and gradually shortened at each daily dressing.

6. **Dressing.**—After a drain has been inserted, its end is fastened with a safety pin and the mastoid cavity loosely packed with 5 per cent. iodoform gauze. The wound may be partly closed above with silkworm gut and the usual mastoid dressing applied.

AFTER-TREATMENT

The patient should remain in bed for at least 4 weeks after the operation until the abscess cavity has filled up and the dural wound healed. If these cases move about too early, they are prone to get up a meningitis or an encephalitis.

Dressings should be done daily for 2 weeks and then probably at less frequent intervals. The patient should be kept on a fluid diet for 4 or 5 days after the operation, and the bowels should be regulated so as to prevent straining during defecation.

PROGNOSIS AND MORTALITY

The prognosis of brain abscess is always grave. The most favorable cases are those in which the cavity is small and superficial, the pus in the abscess not foul, and in which there is a fistulous tract leading directly to the middle ear.

The unfavorable cases die of sepsis and exhaustion, meningitis or encephalitis.

Hernia Cerebri

This condition occurs in the unfavorable cases, and is probably due to an encephalitis in the surrounding tissues. If the hernia is large and gradually increases in size, the outcome is usually fatal. If it is small, the patient may recover.

Digital Exploration

This method is advocated by many general surgeons in cases where the abscess cannot be easily found. It necessitates a large incision in the dura and brain tissue, and I believe that its routine use is fraught with danger to the patient and would reserve it for the last resort in exceptional cases where the symptoms of brain abscess are most positive, but the abscess cannot be discovered by any other means.

CEREBELLAR ABSCESS

Surgical Anatomy.—The anterior and mesial portions of the lateral lobe of the cerebellum are in contact with the petrous pyramid and with the lateral sinus. This is the most frequent site of an abscess and the cerebellum should be explored first in this location. From a surgical standpoint the lateral lobe of the cerebellum is divided into 2 portions: first, the surface anterior to the lateral sinus; second, the surface posterior to the lateral sinus.

The general points in the operative treatment of cerebral and cerebellar abscess are identical; consequently, under this title the author will only consider the special points wherein the surgical treatment of this condition differs from that of cerebral abscess.

Technic of Operation for Cerebellar Abscess

1. Incision.
2. Removal of bone.
3. Exploration for the abscess.
4. Drainage—counter opening.
5. Dressing.

1. The Incision.—This is an extension directly backward of the posterior mastoid incision toward the external occipital protuberance, and of sufficient length so that the triangular flap thus formed, when pushed downward, will expose an area of bone approximately 5 cm. (2 in.) in diameter. In those cases in which the scalp is unusually thick the exposure of this area may be facilitated by carrying the end of this incision slightly downward. It should be carried directly to the bone and the flap immediately reflected downward with the periosteal elevator. During this procedure the mastoid emissary vein will probably be injured; the opening in the bone should be plugged with a bit of iodoform gauze and the scalp end of the vein clamped if necessary. Any muscle fibers adhering to the bone may be cut away with curved scissors.

2. **Removal of the Bone.**—The bone should be first removed over the lateral sinus and over that area bounded by the sinus behind, the dural plate above and the posterior surface of the petrous pyramid anteriorly. Care must be taken not to injure the semicircular canals or the lateral sinus. Injury to the sinus adds considerably to the technical difficulties of the operation and can usually be avoided by the careful use of the rongeur (see Sinus Thrombosis). The bone over the cerebellum, posterior and inferior to the sinus, is of considerable thickness, and in many cases will have to be thinned with the chisel before the rongeur forceps can be used.

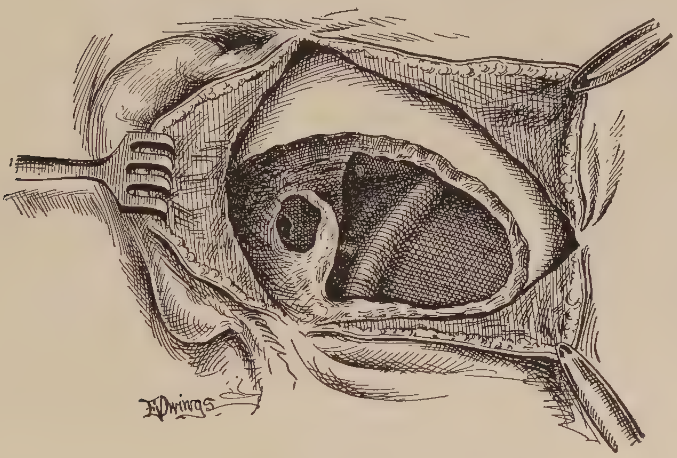

Fig. 29.—Cerebellar Abscess. Showing the area of bone to be removed to adequately expose the cerebellar dura in front of and behind the lateral sinus. In this dissection a Neumann (labyrinth) operation has already been performed. (Drawn from a dissection by the author.)

Behind the sinus an oval area should be exposed, roughly 10 cm. (2 in.) in diameter. Aural surgeons have, for the most part, given up the use of the trephine and depend largely upon the rongeur forceps for the removal of the bone.

During this procedure the mastoid emissary vein is usually again injured. It may be clamped and ligated, or the bleeding controlled by iodoform gauze plugs.

3. **Exploration of the Cerebellum.**—The same general rules of exploration

and treatment governing the cerebrum apply to the cerebellum. If a fistula is found, its opening is enlarged only if necessary. If no visible evidences of a subdural collection of pus are seen, the cerebellum may be explored in the following manner:

In front of the sinus:

1. The knife may be carried directly inward to a depth of not more than 5 cm. (1 in.).

2. A second incision may be made behind the first, inward and a little backward, not deeper than 1⅛ in. (3 cm.).

Behind the sinus:

1. An incision may be made just behind the sinus, inward and forward, to the depth of 1 in.

2. A second incision behind the first, inward and slightly forward to a depth of 1½ in. (2.6 cm.).

3. A third incision posterior to No. 2, directly inward to a depth of 1¼ in. (3.2 cm.).

If the above scheme of systematic exploration (which is due to Kerrison) is unsuccessful, the advisability of other incisions must be considered by the surgeon.

Abscesses in the cerebellum are apt to be small and the pus thick. It is, therefore, easy for the surgeon to overlook an abscess in this locality. On this account, also, I believe the hollow needle to be an untrustworthy instrument for the exploration of brain abscesses of otitic origin.

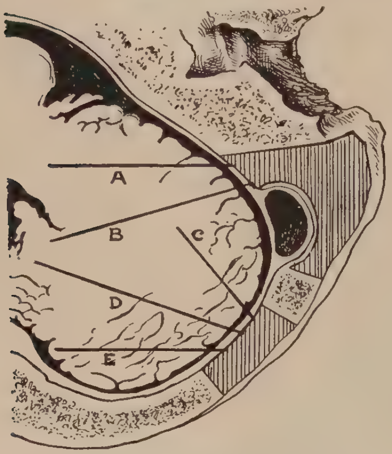

Fig. 30.—Diagrammatic Cross-section of Right Cerebellar Hemisphere. A and B indicate lines of exploration in front of the sinus. C, D, and E indicate lines of exploration behind the sinus. (After Kerrison.)

4. **Drainage of the Abscess.**—If the abscess is located anterior to the sinus, the question of a counter opening arises. Some surgeons advise a counter opening behind the sinus in every case of cerebellar abscess in this locality, but I believe that its use should be restricted to those abscesses which are found to drain improperly through the anterior opening.

During the exploration of the cerebellum and the evacuation of a cerebellar abscess, the patient must be watched for a cessation of respiration. It is wise to have the patient but lightly under the anesthetic and when evacuating an abscess to stop the anesthetic temporarily. The intratracheal insufflation method is especially indicated in cerebellar cases.

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OPERATIONS UPON THE NOSE AND ACCESSORY SINUSES. RHINOPLASTICS

CHAPTER IV

OPERATIONS UPON THE NOSE AND ACCESSORY SINUSES. RHINOPLASTICS

PERCY R. TURNURE

Plastic operations upon the nose are performed for the correction of deformities, sometimes congenital defects, but much more frequently traumatism, inflammation or new growth. Rhinoplastics may be partial or total.

The most common types of inflammation that cause loss of substance of the nose are syphilis, tuberculosis, lupus and noma.

It is a fundamental principle of all plastic work upon the nose that the primary causes of the loss of substance must be completely removed before any operative procedure can be attempted.

To observe the following rules will save many disappointments in rhinoplastic work:

1. When the patient has syphilis (active), give a good course of antisyphilitic treatment before doing any transplantation. In other words, first cure the syphilis.
2. If ulcerations of any kind are present, allow them to heal.
3. After healing of ulcerations, allow ample time for the scar tissue to contract.
4. Avoid the use of strong antiseptic solutions.
5. Flaps should be made at least 1/3 larger than the defect to be covered. Handle all flaps very gently. The viability of the flaps depends almost entirely on the blood supply through the pedicle, which must not be tightly twisted or subjected to tension.

6. "It is well for the surgeon to have fully decided upon the certain operative plan he is to follow several days prior to the operation. He must, especially in total rhinoplastic cases, prepare a paper or oiled silk model of the flap or flaps he has decided upon to take from the forehead or cheek, and to fold or bend this model into the place of the deformity to be overcome to make sure of the result to be obtained, allowing for the loss, if any, of mass by reason of the torsion of the flap at its pedicle" (Kolle, 20).

TOTAL RHINOPLASTY

The operations for total rhinoplasty can be divided into 5 classes, according to the region from which the tissue to be transplanted is taken:

1. The Indian method, in which the flap is taken from the forehead.
2. The French method, in which the flap is taken from the cheek.
3. The Italian method, in which the flap is taken from the arm.
4. The finger method.
5. The German method, in which the flap is taken from the chest.

1. THE INDIAN METHOD

(*After Keegan*)

This method is chiefly applicable in those cases where the soft parts (cartilages, alæ, septum and columnæ) are lost, but in which the nasal bones and the skin over them are intact.

Technic.—FIRST STEP.—Outline the flap on the forehead with a pencil or by a shallow incision. The size and shape will vary according to the amount of tissue to be replaced. The flap should be taken diagonally across the forehead and not vertically, in order not to include any of the scalp. The pedicle should occupy the internal angle of the orbit, and care must be taken not to injure the angular artery which is to nourish the flap (Fig. 1).

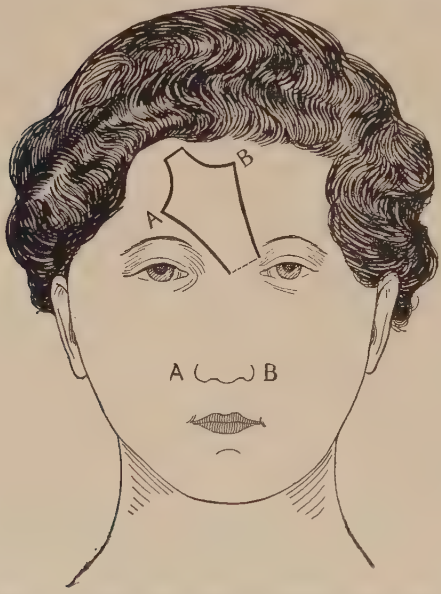

Fig. 1.—Keegan's Indian Method, Showing Outline and Position of Flap on the Forehead.

SECOND STEP.—The second step consists in the preparation of the lining of the nose and the freshening of the edges of the defect. Two converging incisions beginning at a point slightly external to the roots of the alæ of the nose extend upward to 2 points, about ¾ in. apart, on the bridge of the nose, CA and HF; and A and F are joined by a horizontal incision a short distance above the margin of the defect. From the center of this incision a perpendicular incision extends downward to a point where the cartilages join the nasal bones, BE, DG. Two quadrilateral flaps, CABD and HFEG, are thus formed. These 2 quadrilateral flaps are folded down so that their cutaneous surfaces line the nasal cavity, after which what remains of the edges of the defect are freshened. (Fig. 2.)

The flaps, when folded down, allow 2 triangular pieces to overlap in the center. Keegan removes these pieces and transplants them into the forehead wound. Smith (32), instead of cutting away the 2 triangular pieces, splits the old septum and sutures the edges of these pieces into the sides of the septal wound, thereby forming a septum and columna.

THIRD STEP.—The outline incision of the flap is deepened, cutting all tissues down to but not through the periosteum. Separate the flap from the forehead with as little handling as possible, and twist the flap down over the nose. In order to facilitate this twisting, the hinge has been made oblique, starting higher on one side than on the other.

FOURTH STEP.—The 2 raw surfaces are now lying in apposition. The inferior margins of the quadrilateral nasal flaps and the forehead flap are sutured together. The portion of the flap cut for the columna is fitted into a bed, at the site of the old columna, which was prepared for it when the edges of the defect were freshened. The 2 original incisions, CA and HF, are now deepened and beveled for the reception of the lateral margins of the flaps which are sutured to them.

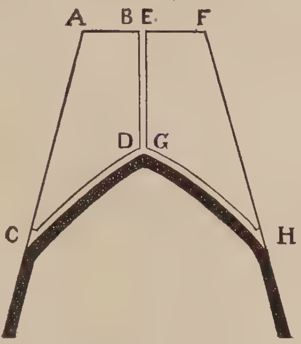

FIG. 2.—KEEGAN'S INDIAN METHOD, SHOWING INCISION FOR FORMATION OF NASAL FLAP.

FIFTH STEP.—The sides of the forehead wound are approximated.

SIXTH STEP.—Insert drainage tubes into each new formed nostril and apply boric acid ointment dressings over the lateral margins of nose and cheek.

SEVENTH STEP.—The seventh step is the division of the pedicle. A fortnight after the original operation, a wedge-shaped piece of tissue is removed from the pedicle, making the forehead smooth.

There have been many modifications and some improvements of this method. They have practically all been based upon the fact that, without nasal bones to support it, the transplanted substance results in a flat nose. To overcome this, pieces of cartilage or bone are transplanted with the flap.

Koenig's Operation.—In 1886 Koenig described one of the first osteoplastic flap operations (Fig. 3).

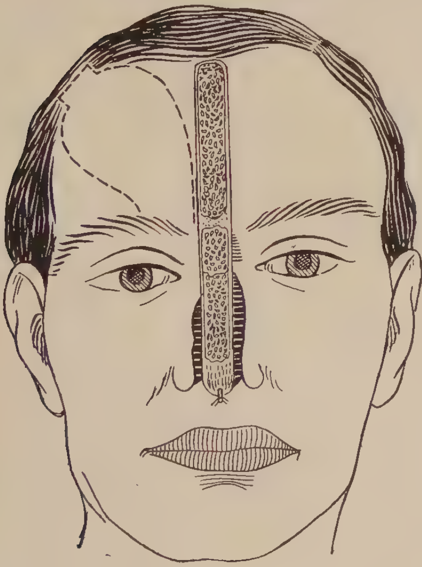

FIG. 3.—KOENIG'S OPERATION, SHOWING SKIN-PERIOSTEUM-BONE FLAP CUT AND TURNED DOWN WITH ITS BONY SURFACE OUTWARD; ALSO INCISION FOR FOREHEAD FLAP.

FIRST STEP.—A skin-periosteum-bone flap is made 1 cm. wide. The flap begins at the root of the nose and extends directly upward to the hair line. This flap is turned down with the bony surface out. One centimeter from the lower edge, the bone is fractured transversely to allow the lower portion to form the columna. The lower edge is sutured into the freshened edge of the old columna.

SECOND STEP.—This raw surface is covered with a forehead flap after the Indian method.

Schimmelbusch's Operation (31).—Fig. 4, A.—FIRST STEP.—A periosteum-bone-skin flap is made from the forehead large enough to cover the defect, with a base of from 7 to 9 mm. wide. The flap reaches from the root of the nose directly upward to the limit of the hairy scalp. As soon as it is lifted, the flap is wrapped in iodoform gauze.

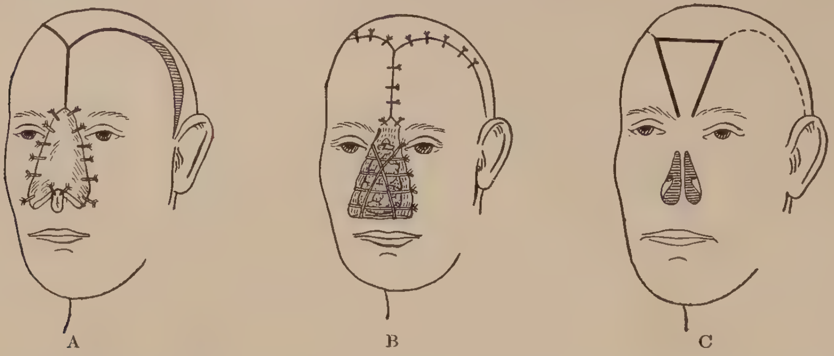

FIG. 4.—SCHIMMELBUSCH'S OPERATION. A, Position and shape of flap from forehead. B, Periosteum-bone-skin flap turned down and wrapped in iodoform gauze and wound in forehead covered by sliding flaps. C, Flap sutured in position and covered with skin grafts.

SECOND STEP.—The forehead defect is covered in by sliding flaps from the scalp. (Fig. 4, B.)

THIRD STEP.—The periosteum-bone-skin flap is left in iodoform gauze for from 4 to 9 weeks, which allows the dead bone to slough away and the entire area to be covered with granulations. These granulations are then removed and the entire raw surface is covered with Thiersch grafts.

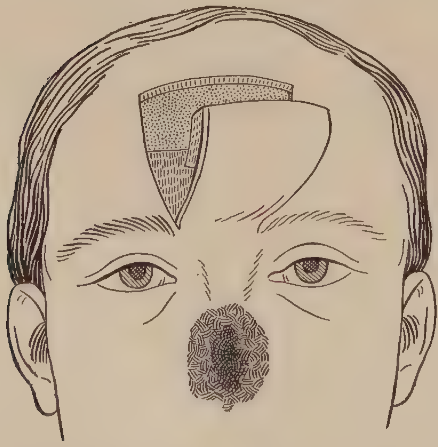

FIG. 5.—LEXER'S OPERATION, SHOWING FORMATION OF FOREHEAD FLAP BENT UPON ITSELF.

FOURTH STEP.—When the grafts are healed, the bony plate is sawed from the grafted side at the middle line, with a fine saw, to allow the flap to be modeled into the shape of a nose.

FIFTH STEP.—The edges of the nasal defect are freshened and the septum is formed from the tissue removed from these edges. The flap is then twisted into position with the newly formed epidermis turned to the inner side and sutured to the freshened edges of the defect.

SIXTH STEP.—Several subsequent minor operations, done under cocain, are often necessary for the cosmetic result.

Lexer's Operation (21).—This is a modification of Schimmelbusch's operation to obviate the necessity of waiting for the granulations to form and the Thiersch grafts to take.

FIRST STEP.—All the scar tissue which may obstruct the respiration is curetted away, and the raw areas are covered with skin flaps from the remnants of the adjacent skin. These flaps are not sutured, but are held in place by gauze tampons until union takes place. The skin over the root of the nose should be carefully guarded against injury, as it is used to form the pedicle of the flap. (Fig. 5.)

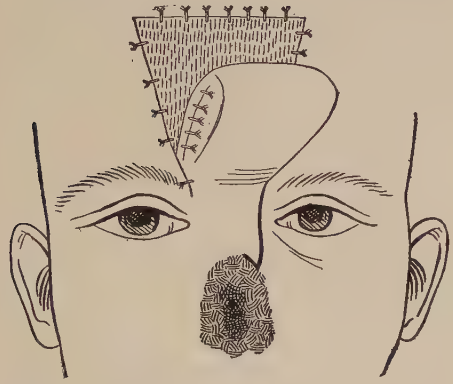

FIG. 6.—LEXER'S OPERATION, SHOWING THE TWO RAW SURFACES OF THE FLAP SUTURED TOGETHER.

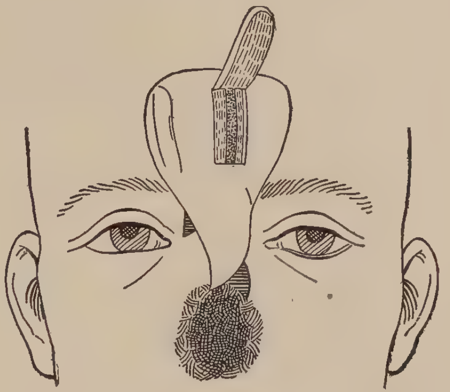

FIG. 7.—LEXER'S OPERATION, SHOWING FORMATION OF PEDICLE AND SEPTUM.

SECOND STEP: FORMATION OF THE FOREHEAD FLAP.—A large flap with a broad base is cut from the forehead. The upper half of the flap should include the periosteum and some bone. The flap is then bent in the middle and the 2 raw surfaces of the flap are sutured to each other, giving the bone a layer of skin on both sides. The forehead wound is closed with skin grafts. (Fig. 6.)

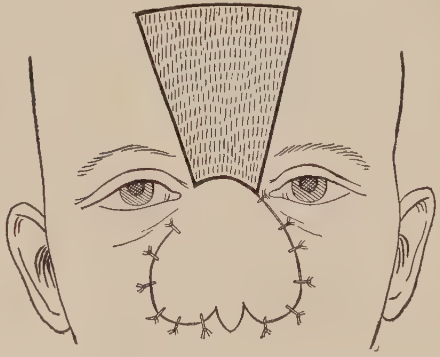

FIG. 8.—LEXER'S OPERATION, SHOWING THE EDGES OF THE PYRIFORM FOSSÆ AND THE EDGES OF THE FLAP FRESHENED AND SUTURED TOGETHER.

THIRD STEP: FORMATION OF A PEDICLE.—Three to 4 weeks after the first procedure, when the blood supply to the forehead is assured, the formation of the pedicle is begun. This step is carried out in several stages, in order not to interfere with the blood supply. On one side the incision is made down to the nasal defect, and on the other to the inner canthus of the eye. In order that the pedicle may be turned without torsion, the skin is separated from the underlying bone on the side of the longer incision. The separation may have to be carried as far as the mid line. (Fig. 7.)

FOURTH STEP: FORMATION OF THE SEPTUM.—From the middle of the under surface of the flap, cut a strip of skin 1 cm. wide down to the bone plate. Leave the skin pedunculated near the future tip of the nose. This is to be used for the septum. Through this wound the bone is split with a fine saw in the middle line to allow it to be bent to the shape of a nose. The edges of the pyriform fossæ and the edges of the flap are freshened and sutured together. (Fig. 8.)

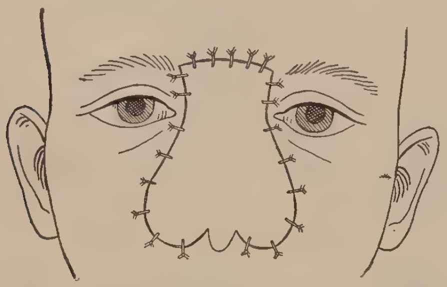
FIG. 9.—LEXER'S OPERATION, SHOWING PEDICLE CUT AND FLAP TURNED UPWARD TO FILL THE GAP BETWEEN THE EYEBROWS.

FIFTH STEP: CUTTING THROUGH THE PEDICLE.—This step is delayed as long as possible, for when it is performed too early, especially in syphilitics, the bone is apt to be absorbed. The pedicle is cut to allow a flap which is turned upward to fill in the gap between the eyebrow and sutured carefully into place. (Fig. 9.)

SIXTH STEP: FORMATION OF THE NORMAL DEPRESSION BETWEEN THE NOSE AND THE FOREHEAD.—This is done several weeks after the pedicle has been cut. An incision is made through the scar tissue at the inner canthus of the eye, about 2 cm. long. The scar tissue, with all the tissue down to the bone, is excised. The tissue at the root of the nose is lifted and all the edematous and thickened connective tissue is removed. The skin is then pressed down upon the bone. The slight excess of skin, which will be found on both sides, is removed by an incision convex toward the nose (Fig. 10).

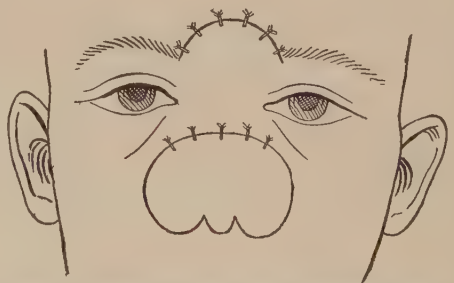
FIG. 10.—LEXER'S OPERATION, SHOWING FORMATION OF DEPRESSION BETWEEN NOSE AND FOREHEAD.

SEVENTH STEP: FORMATION OF THE POINT OF THE NOSE.—This is done by transplanting a piece of bone or cartilage from the rib of the same patient or another. A symmetrically curved incision is made along the lower border of the newly formed nose, and the skin is lifted from the underlying transplanted bone. An oval piece of bone or cartilage is prepared, slightly convex on its periosteal side and with a slight groove on its non-periosteal side, for lodgment against the transplanted bone. This piece is then properly placed in the bed prepared for it. This makes the curved incision gape slightly. This is not sutured, and the wound is allowed to heal by granulation. The newly transplanted bone may have to be held in by a needle.

EIGHTH STEP: FORMATION OF THE ALÆ.—The connective tissue of the scar in the curved incision causes a slight depression on the sides of the nose which may be used as the anterior margin of the alæ. In order to make this more pronounced and also to thin out the much thickened alæ, a slightly curved incision is made in the nostril and the subcutaneous tissue on the inner side of the bony framework is removed. A small notch is then cut in the bone with a fine bone forceps on both sides. In this way, not only is the nostril widened, but the notch is also deepened.

NINTH STEP: FORMATION OF THE OUTER MARGIN OF THE ALÆ.—A small amount of skin is excised from the external edge of the new nose. This rounds out the ala. The edges of the wound, instead of being united, are sutured to the subcutaneous tissues, thus deepening the curve.

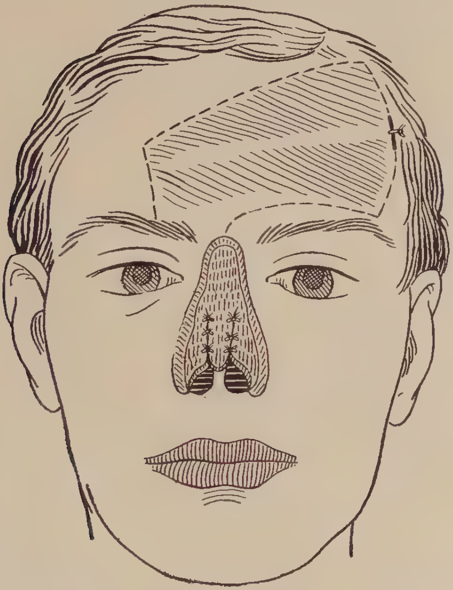

FIG. 11.—NÉLATON'S OPERATION, SHOWING FLAP OUTLINE ON FOREHEAD WITH TUNNEL INTO WHICH THE STRIP OF CARTILAGE IS PLACED.

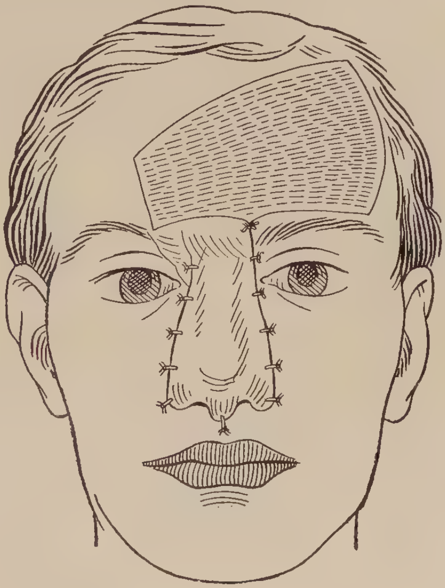

FIG. 12.—NÉLATON'S OPERATION, SHOWING ROTATION OF FLAP CONTAINING CARTILAGE AND POSITION OF SUTURES.

Nélaton Operation.—Instead of using part of the bony framework of the forehead, Nélaton transplants a piece of cartilage underneath the skin, which he intends to use for the flap.

FIRST STEP.—The costal cartilage of the eighth rib is excised and trimmed until it is about 2½ mm. wide.

SECOND STEP.—A flap is outlined on the forehead (Fig. 11), and a horizontal tunnel is made in the middle of it, under the periosteum, wide enough to take the strip of cartilage which is introduced into this tunnel. The cartilage has previously been notched at the point where it is to be bent for the columna.

THIRD STEP.—The skin which covers the remnants of the nose is made into 3 flaps. The portion covering the base is turned down, and the skin covering the sides are turned in and sutured together.

FOURTH STEP.—The forehead flap, with its pedicle at the inner border of the eyebrow, is cut with the transplanted cartilage in the center of the flap. The flap is rotated and sutured over the prepared raw surfaces. The cartilage is bent at the nick, and the forehead skin covering it is sutured into freshened base of the old columna. (Fig. 12.)

FIFTH STEP.—The frontal wound is closed with skin grafts.

SIXTH STEP.—Any cosmetic operations on the pedicle which prove necessary are done.

2. FRENCH METHOD

The essential feature of this method consists in the use of flaps taken from the cheeks for the formation of the new nose. It is not recommended, because the marked contraction of the scar tissue in the cheeks soon flattens the newly formed nose to almost the level of the rest of the face.

Syme's Operation.—The Syme's operation is a typical example of this method (Fig. 13).

FIRST STEP.—From each cheek, form a flap which has its pedicle at the root of the nose.

SECOND STEP.—The inner edges of the flaps are united down the center line and the outer edges are sutured to the freshened edges of the defect.

THIRD STEP.—The cheek wounds are closed with sutures or skin grafts and a tube is placed in each nostril.

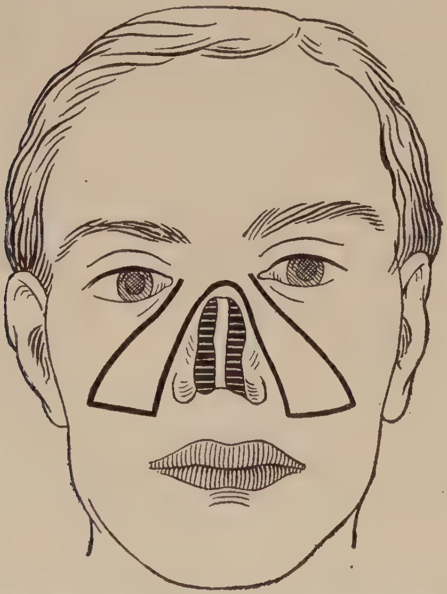

Fig. 13.—Syme's Operation, Showing Outline of Flaps Made From Cheeks.

3. ITALIAN METHOD

The restoration of a nose by means of a flap of skin taken from the arm is an operation of Italian origin, Gaspard Taglacozzi (or -cotti) being the first to use it in 1597. The special feature of the operation is the pedicle which is left when the flap of skin is raised from the upper arm, and which is not divided until after the free portion of the flap has united with the nose. This method is now only used when there is no available tissue on the face; or when the operator wishes to avoid further scarring of the face.

Technic.—FIRST STEP.—(After MacCormac, 22).—"Provide a means whereby with the minimum of inconvenience, the patient's arm may be kept in the needful position for the requisite period." This is from 1 to 3 weeks (Figs. 14, 15, 16 and 17).

SECOND STEP.—A gutta-percha model is made for the nose, and from this model is planned the flap to be taken from the arm. The flap should consist of skin and subcutaneous fat and should be twice the required size, to allow for shrinkage. A piece of tissue for the septum is planned at the same time. The anterior surface of the left upper arm near the elbow is used.

THIRD STEP.—When the flap, including the small piece for the septum, has been marked out on the arm, it is raised from the subjacent tissues for its entire length, but not cut free, leaving the 2 ends attached. Sterile rubber tissue is then placed under this bridge, and the surfaces are allowed to granulate for 1 week under the most perfect aseptic conditions. By this method the tissues of the flap thicken, and its circulation is reëstablished before it is attached to the face.

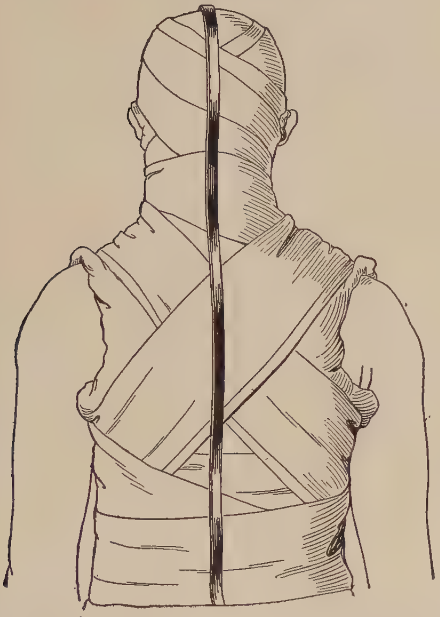

FIG. 14.—NÉLATON'S METHOD FOR THE FIXATION OF THE ARM TO THE HEAD, SHOWING APPLICATION OF COTTON AND FOLDED GAUZE PADDING AND MOULDED IRON STRIP.

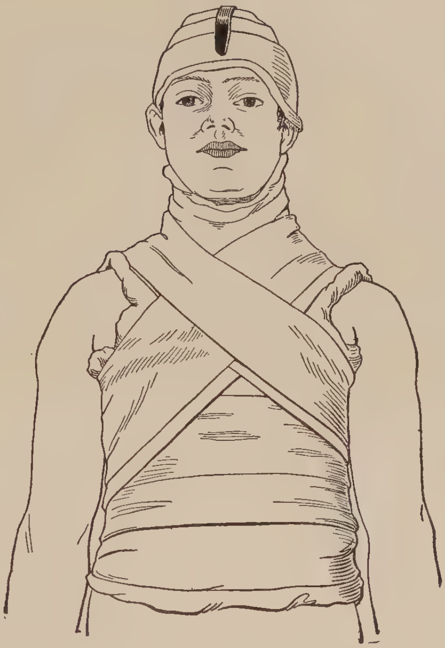

FIG. 15.—FRONT VIEW OF FIGURE 14.

FOURTH STEP.—The upper end of the flap is separated from the arm, a slightly curved incision is made parallel to the border of the defect on the right side, and the edge of the flap is sutured into this incision.

FIFTH STEP.—After 3 weeks the flap is cut from the arm, and the septum and the other side of the flap are sutured into freshened edges of the nose.

SIXTH STEP.—Minor operations are performed that may be necessary for a cosmetic result.

Lexer's Operation.—This method is a modification of the preceding one. A piece of bone, of the dimensions desired for the bony structure of the nose, is cut from the femur and transplanted under the skin of the arm. When it is well established, a flap including the bone is cut in the arm and transplanted to the nose.

Israel's Operation (13).—A flap is made from the inner side of the forearm, and a piece of the ulna is taken with the skin flap to give it a bony framework.

Steinthal's Operation (33).—A flap cut from the skin of the sternum, with its periosteum, is transplanted to the forearm. After the graft has taken, the flap is transplanted from the forearm to the nose.

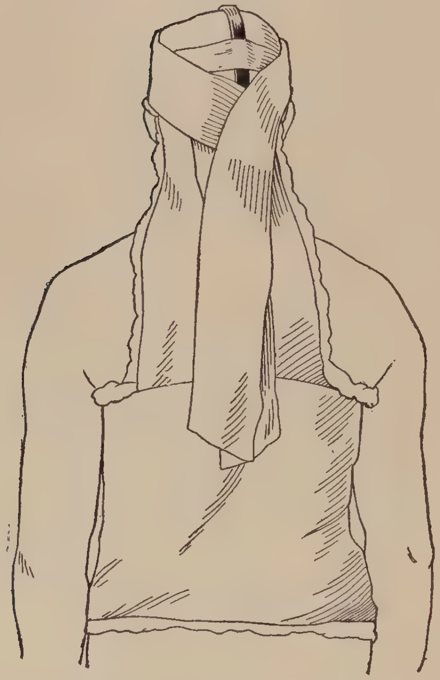

Fig. 16.—Nélaton's Method, Showing Application of Heavy Plastic Strips Over Previously Applied Padding.

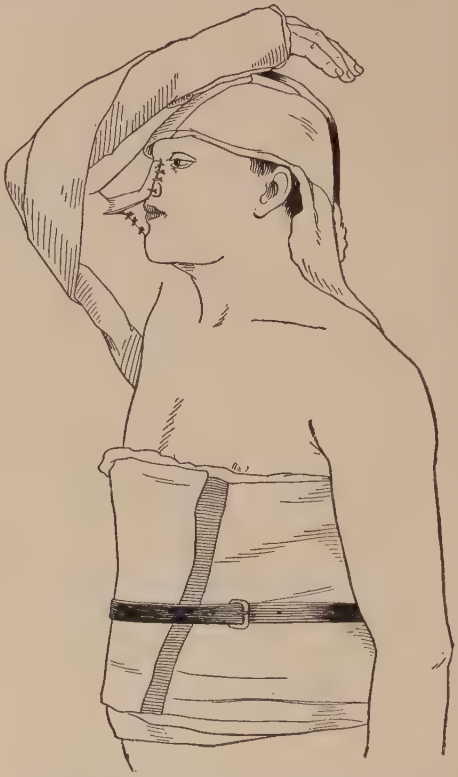

Fig. 17.—Nélaton's Method, Showing Arm Fastened to Head. It will be noted that all padding has been removed from the upper part of the chest and that the cast overlaps in front and is fastened by a leather strip.

4. FINGER METHOD

This is another method by which the lack of bony framework in skin flaps is overcome. It was probably first performed by James Hardie in 1875 (10). His result seemed satisfactory for a while, but later, through lack of support, the new nose receded into the nasal cavity. Sabine (30) had a similar case in 1882. He, however, used the first phalanx of the finger as the columna.

Of late years the use of the finger in rhinoplastics has again come into favor. Wolkowitsch, McWilliams, Baldwin, Finney, and McGraw all have reported successful results.

Baldwin's Operation (1).—This is a very good modification of the finger method. The finger is used for the exterior surface of the nose, which is lined with flaps taken from the abdominal wall.

FIRST STEP.—The skin on the palmar surface of the left ring finger is split, and all the tissues down to the bone are dissected back on both sides (Fig. 18, 1).

SECOND STEP.—A rectangular flap of skin is dissected up from the anterior abdominal wall (Fig. 18, 2), and this is sutured to the deflected skin of the finger so that the finger is covered on both sides by skin and has 2 broad lateral expansions. These projecting sides are tied to a large piece of perforated copper—like bats' wings—to prevent contraction. The gap in the abdominal wall is closed by sliding flaps.

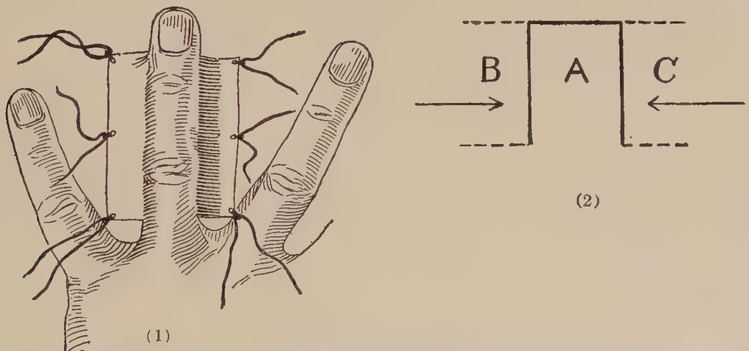

FIG. 18.—BALDWIN'S OPERATION. (1) Back of ring finger with palmar flaps extended to apply to A. (2) Flap A to be dissected up and laid back to apply to flaps on finger B and C to be undermined and brought together to cover raw surface.

THIRD STEP.—Two weeks later the skin flap is cut from the abdominal wall.

FOURTH STEP.—After another period of about 2 weeks, the arm and head are placed in a plaster bandage. The bandage, when thoroughly dry, is split up the side. The following day remove the skin, nail and matrix from the tip of the finger. The edges of the sides are trimmed and slightly split. The tissues at the root of the nose are trimmed and treated in such a way that the bone of the finger tip may come in contact with the frontal bone. The edges of the nasal cavity are freshened and the lateral edges are sutured into their proper places.

FIFTH STEP.—Three weeks later 1 digital artery is tied and cut. A few days later the other digital artery is cut, and the finger amputated.

SIXTH STEP.—The first phalanx is turned up to form the columna.

SEVENTH STEP.—Minor operations may have to be done for cosmetic result.

McWilliam's Operation (24).—The finger is used, but no lining for the nose is provided for.

FIRST STEP.—The night before the operation, the arm and head are placed in a plaster-of-Paris bandage. The cast is split up the side so as to be readily removed in case of anesthetic accident.

SECOND STEP.—The soft parts at the root of the nose are lifted, but not cut. An Esmarch bandage is placed about the arm. The nail-bed with its nail and the skin from the whole circumference of the last phalanx is removed. The tip of the last phalanx is removed with a rongeur. The metacarpophalangeal joint is opened posteriorly. The head of the metacarpal bone is removed and the anterior tendons are divided. **The digital vessels must not be injured.**

THIRD STEP.—The denuded bone of the finger tip is placed against the frontal bone under the bridge of undivided soft parts.

FOURTH STEP.—A longitudinal strip of skin is removed on each side of the finger about ¼ in. wide. The edges of the nasal remnants or cheek are beveled to make a point of attachment for the skin from the finger.

FIFTH STEP.—Fifteen days later, the digital vessels on one side of the finger are tied and cut, thus slowly reëstablishing the circulation.

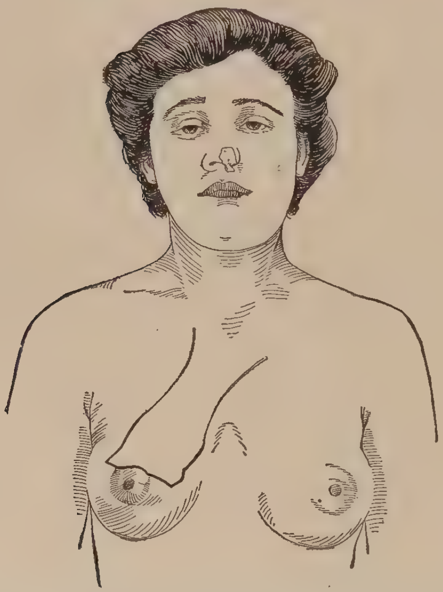
FIG. 19.—E. HOLLANDER'S OPERATION, SHOWING SHAPE AND POSITION OF FLAP TAKEN FROM THE CHEST.

SIXTH STEP.—On the twenty-first day the finger is amputated.

SEVENTH STEP.—The proximal phalanx is flexed and sutured to the freshened base of the nose.

EIGHTH STEP.—Minor operations may have to be done for a cosmetic result.

5. GERMAN METHOD

E. Hollander's Operation (11).—This operation makes use of a method of rhinoplasty particularly adapted to women, in which the skin covering the sternum is used.

FIRST STEP.—A breast and head bandage of plaster-of-Paris is placed in order to approximate the 2.

SECOND STEP.—A flap of skin is excised from over the sternum according to Figure 19.

THIRD STEP.—The skin over the nose is freshened, and the upper portion of the flap is sutured to the freshened area. The upper portion of the chest wound is drawn together and sutured, and the lower portion is covered with a dressing and left for the reception of the unused portion of the flap.

To prevent infection of the raw surface, it must be covered with rubber tissue or some impermeable material.

FOURTH STEP.—The flap is cut through on the fifth day and sutured to the freshened edges of the nose remnants. The excess of skin is put back on the raw area of the chest.

It is only when the distance from the areola of the nipple to the opposite sterno-clavicular articulation is equal to or greater than the distance from the areola to the root of the nose (with head bent and breast raised) that this method can be used.

Rosenstein's Operation (29).—This method is a modification of the preceding one. The skin from the sternum is transplanted into the chin and, after union has taken place, the flap is transplanted from the chin to the nose. This procedure obviates the discomfort of a long operation with the head and breast held in plaster.

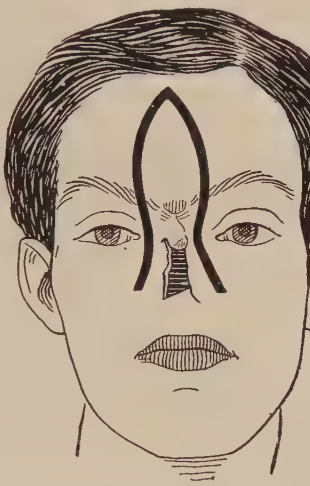

FIG. 20. — NÉLATON'S OPERATION, SHOWING SHAPE AND POSITION OF FLAP.

NÉLATON'S RHINOPLASTIC OPERATION

This is one of the methods for complete rhinoplasty, of which there are several, which does not regularly belong under any of the preceding classifications (26). This procedure is applicable in all cases where a nasal stump is left which has a protuberance of at least 7 or 8 mm.

Technic.—FIRST STEP.—A horseshoe-shaped flap is cut around the defect formed by the destruction of the nose. Standing on the left side of the patient, the operator begins the incision on the right cheek at a point situated a finger's breadth from the nasal fossa, on a line from the anterior's nasal spine to the lobe of the ear. The incision goes upward, following the nasogenial furrow, and passes 6 mm. inward of the lacrimal caruncle to the eyebrow, which it divides at its inner end in a vertical direction. After passing the eyebrow, the incision continues directly upward for a short distance, and then slants inward to reach the edge of the hairy scalp in the middle line. The same incision is now made on the left side from below upward, terminating at the same point, near the edge of the scalp. (Fig. 20.)

SECOND STEP.—The frontal flap is dissected free from the bone at its tip and margins only, leaving a long mesial strip of the flap adhering to the bone from the upper extremity to the level of the frontal sinus. One of the dissected sides of the flap is turned back by an assistant to allow the operator to trace a furrow with a chisel through the external layer of the diploë, upward from the frontal sinus to a point near the extremity of the flap. The same procedure is repeated on the opposite side, and an effort is then made from above downward to detach, by means of a fine flat chisel, the strip of the thin outer layer of the diploë. Near the frontal sinus, this strip, which adheres to the flap for a width of about 3 cm., is separated completely from the bone. The dissection, which had reached as far as the frontal sinus, is then continued lower down and the bony framework of the root of the nasal bones is exposed. These bones are exposed to an extent of 6 to 8 to 10 mm., according to the size of the nasal stump.

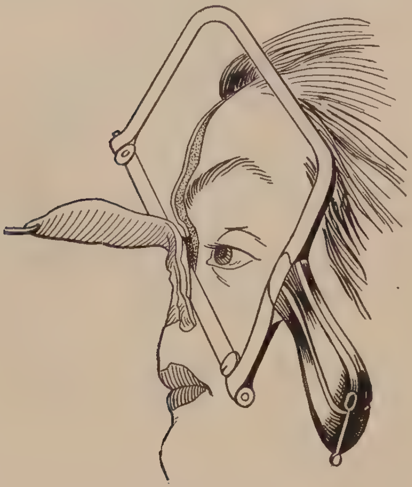

Fig. 21.—Nélaton's Operation, Showing Sawing of Nasal Bones to Free Flap.

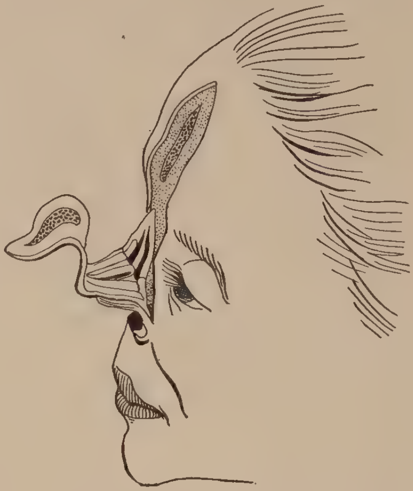

Fig. 22.—Nélaton's Operation, Showing Bending of Flap to Establish Shape of New Nose.

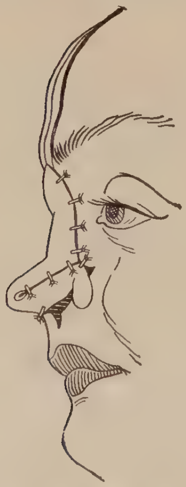

Fig. 23.—Nélaton's Operation, Showing Suture of Flap.

THIRD STEP.—The bones of the nose are cut with a saw (Fig. 21), passing from above downward and backward, and dividing the ascending process of the superior maxilla. The instrument follows a line beginning 1 cm. in front of the anterior nasal spine and reaching toward the second molar. The cut ends a little below and 6 to 7 mm. in front of the suborbital foramen. The division of the bones can be accomplished without difficulty, provided the soft parts have been freely incised and the course of the saw has been plainly exposed.

FOURTH STEP.—Having reached the point indicated, the saw is withdrawn and the root of the ascending process is fractured by means of a gouge which has been introduced into the wound on each side. This separation must be made cautiously and is left incomplete. In lowering the flap and the nasal structures, the operator completes this fracture in such a way that the ascending process remains loosely connected with the body of the maxilla, adhering slightly by some bony fibers.

FIFTH STEP.—The flap is folded together (Fig. 22) and the tip of the nose, formed by the summit of the nasal stump, is held in the desired position by an assistant. The flap is sutured as shown in Figure 23, thus forming a nose which receives its dorsal support from the strip of osseous tissue which has been detached from the frontal bone.

The elliptical space which is left on the forehead is covered with Thiersch skin grafts. The nostrils and the lower part of the septum are formed in a second operation, which is planned according to the conditions that exist.

PARTIAL RHINOPLASTICS

Operations for partial rhinoplastic restoration deal essentially with the repair of the loss, through accident or disease, of the lateral wall, the wings, the tip of the nose or the nasal septum. For repairing these defects, flaps may be taken from the cheek, the lip, the normal side of the nose, or the arm.

REPAIR OF THE ALA

Von Langenbeck's Operation (Fig. 24).—This author makes a quadrilateral flap with its pedicle to one side of the center line and on the affected side. The lower part of the flap should include a piece of the cartilage of the alæ, but not all the thicknesses of nasal tissues. This flap is brought over and sutured into freshened edges of the defect. The raw surface left on the healthy side, as the result of removing the flap, is at once covered with Thiersch skin grafts.

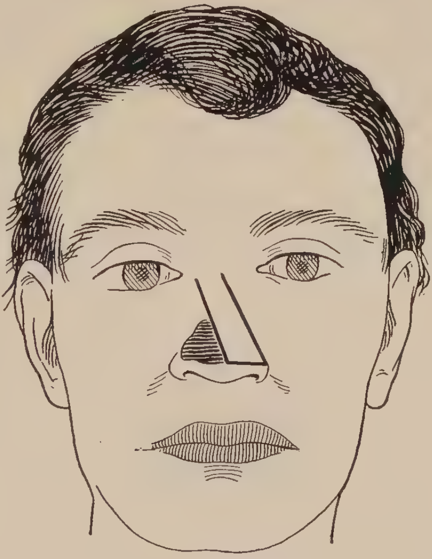

FIG. 24.—VON LANGENBECK'S OPERATION, SHOWING SHAPE AND POSITION OF FLAP.

Nélaton's Operation.—This procedure is practically the same as von Langenbeck's. The flap is taken from the cheek, but has no cartilaginous support (Fig. 25).

Von Hacker's Operation (9).—This method (Fig. 26) modifies the von Langenbeck technic by lining the flap transplanted from the healthy side of the nose with the skin of the cheek. Von Hacker first cuts a quadrilateral skin flap from the cheek on the defective side and turns it so that the skin side is toward the inside of the nose, thus partially closing the defect. Over this raw area he transplants a flap of skin taken from the healthy side of the nose, according to the von Langenbeck technic.

Carl Beck's Operation (4).—This method was used on a patient who had a recurrent epithelioma of the nose, and on whom several rhinoplastic operations had been already performed. In the previous operations, the cheek, forehead and arm had been used.

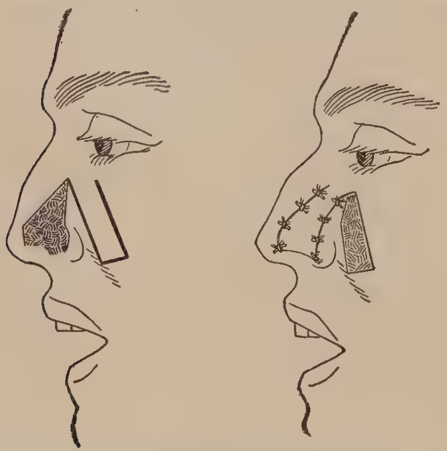

Fig. 25.—Nélaton's Operation, Showing Shape, Position and Suture of Flap.

A triangular flap was cut from the lower lip and rotated into the defect, using the angle of the mouth for the bridge. The lip wound was closed with sutures.

Several secondary cosmetic operations were performed, and the result was most satisfactory.

Fritz Koenig's Operation (19).—This author maintains that a piece of tissue, to be of any value in the wall of the nose, must have epithelium on both sides. He excises a piece of the concha of the ear and makes a free transplant into the defective area of the alæ. Lexer has used this method and advises the addition of a large skin flap, so that there will be a large area of coaptation.

Tunis's Operation (34).—In a case described by this author, the skin of the finger was used to overcome the loss of an ala. The phalanges and tendons were removed through an anterior incision, and the nail cut away. The edges of the defect were then freshened, and the skin of the finger sutured to the nose. At the end of 3 weeks, the stump of the finger was amputated. The result was good.

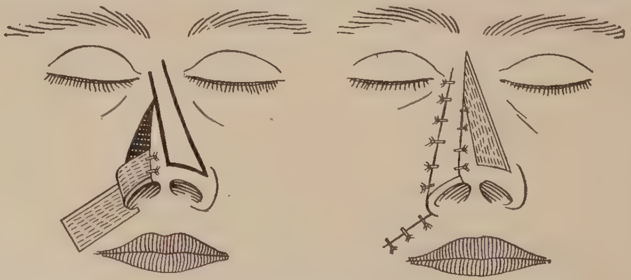

Fig. 26.—Von Hacker's Operation, Showing Shape, Position and Suture of Flap.

Denonvillier's Method (Fig. 27).—A triangular flap is cut with its base along the margin of the defect and with its pedicle at the tip of the nose on the farther side. The loosened flap is slipped downward so that its base becomes the free margin of the new nasal wing. This base is fixed by sutures to the lateral edges of the defect, which have been previously freshened. The raw area from which the flap is taken may be allowed to heal by granulation, or covered at once with skin grafts.

Joseph's Operation for the Repair of Broad Defects of the Nasal Alæ.—A vertical incision is made along the mesial margin of the defect, parallel to the middle line, through the entire thickness of the lateral wall. The length of this incision must be equal to about ⅔ of the entire length of the nose. Another incision is made upward from the pyriform fossa, leaving a pedicle at that point which meets the first one at the level of the orbital margin. The flap thus formed is lowered into the defect and fastened into position by sutures. The margins of the wound, made by the removal of the flap, are stitched together.

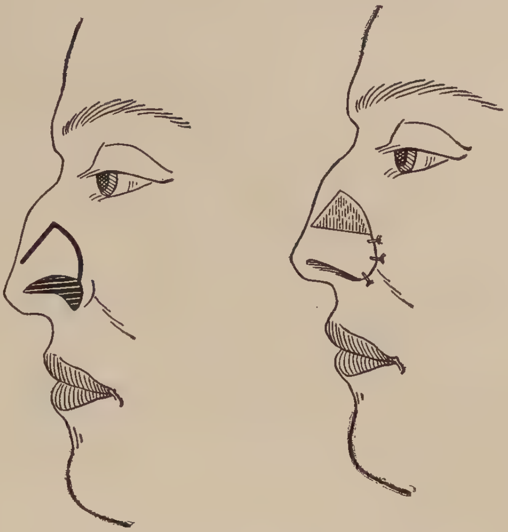

Fig. 27.—Denonvillier's Operation, Showing Shape, Position and Suture of Flap.

Joseph's Method with Transplantation of Non-pedunculated Skin Flaps Taken from the Nose (16).—In this procedure the defect of one nasal ala is replaced by a completely detached piece from the other undamaged ala. The steps of the operation are as follows: One blade of a pair of strong, curved scissors is introduced into the nostril of the normal side; the other blade is placed exactly upon the nasolabial fold; and the ala is detached from the cheek with 1 cut of the scissors. A second cut is then made with the scissors through the entire thickness of the ala, about 5 mm. from the first incision, parallel with it for about ⅔ of its length, then gradually approaching the first incision and meeting it at its highest point. A curved segment is thus entirely excised from the normal ala, and is immediately transplanted into the freshened edges of the defect. The transplant must be carefully sutured, and any overstretching of the parts must be avoided. Finally, the area where the flap has been removed is closed by sutures. Joseph maintains that, when the operation has been properly performed, no mutilation need be feared at the site of the removal of the transplant. This method is especially recommended in cases where the defect of the ala is not very wide, and where the tip of the nose is somewhat protuberant. The tip of the nose is usually retracted as a result of the operation.

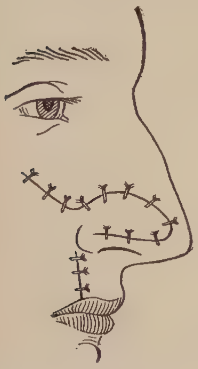

Fig. 28.—Bryant's Operation, Showing Jumping Flap Method.

Bryant's Method.—Bryant describes what he calls a jumping flap for a defect in the ala (Fig. 28). The flap is made 1¼ times as large as the defect, otherwise when contraction of the scar takes place the nose may be deviated.

To stiffen a newly formed ala or lateral wall and prevent it from collapsing with each inspiration, a piece of costal cartilage may be transplanted into the tissue used for making the wing of the nose, in the manner described in procedures for total rhinoplastics. In the same way, when the defect is large, material for its repair may be taken from the forehead or arm.

RESTORATION OF NASAL SEPTUM

The dorsum of the nose may be used for the formation of a new septum. A narrow, oblong rectangular flap is excised, including some cartilage, to strengthen the septum, extending from near the tip of the nose to the nasal bones, and having its pedicle at its upper end. Through the split thus formed the edge of the defective septum is freshened, and the flap is turned edgewise into the gap and sutured to it. The 3 edges, the lateral edge of the flap and the edges of the wound, are then sutured together.

A flap from the floor of the nasal cavity, consisting of mucous membrane, periosteum and bone, has been utilized for the formation of a new septum by Tillmanns and by Hahn.

RESTORATION OF THE COLUMNA

Roe's Operation (28).—Roe and Lexer use the mucous and submucous structures on the under side of the lip, bringing them through a perforation at the base of the columnæ. Roe, after pushing the flap through the opening, folds it on itself and sutures the raw surfaces to each other, leaving 2 mucous membrane surfaces for the new columnæ. The original tip of the flap is then sutured to the remnants of the old columnæ, and its new upper side is sutured to the remnants of the septum, thus reconstructing a columna and septum.

This operation causes less deformity and avoids more disadvantages than most of the other operations.

Dieffenbach's Operation.—This method makes use of a lateral flap from the lip. Two horizontal incisions go through the entire thickness of the lip. The flap thus formed has its pedicle lying obliquely under 1 nostril, and is turned and sutured with its free end to the tip of the nose. The wound in the lip is drawn together with sutures. The objections to this procedure are twofold: The hairy surface of the flap gives much annoyance, and the lip is apt to be drawn out of its normal position on the wounded side.

A variation of this operation, which Dieffenbach also cites, is the use of a flap cut through all the thicknesses of the lip vertically, and immediately under the columna, with its pedicle at the base of the columna. This is turned upward with the skin surface interior and the mucous membrane exterior. This also has the disadvantage of no end of annoyance from the hairy surface.

McGraw's Operation (23).—The last phalanx of the little finger is grafted to form the columna.

FIRST STEP.—The nail and matrix are removed. Two longitudinal incisions, 1 on the dorsal and 1 on the palmar surface of the finger, are made, extending from the tip of the finger to the distal end of the first phalanx.

SECOND STEP.—The second phalanx and the distal end of the first phalanx are removed. The digital arteries must not be injured.

THIRD STEP.—The inner surface of the tip of the nose is freshened and the freshened tip of the finger is sutured to it. The area over the nasal spine of the superior maxilla is freshened, and the base of the last phalanx is sutured to this denuded surface. Splints are arranged to keep the head and arm in position.

FOURTH STEP.—At the end of 30 days the finger is amputated.

The second phalanx and the distal end of the first were removed in order that the bridge which connected the grafted tissues should be pliable and so protect the new wounds against any sudden movements.

Von Langenbeck uses a skin flap from the lip.

Hueter uses the skin from the nose itself and rotates it into the defect.

RESTORATION OF THE TIP OF THE NOSE

Wolff's Operation for the Repair of the Tip.—A tongue-shaped skin and bone flap is formed from the upper part of the nose, having an inferior base. Under the flap the nose is divided into 2 halves by 2 transverse incisions, and the lower half, with the tongue-shaped skin and bone flap, is drawn down. The wound on the dorsum of the nose is united, and the apex of the flap fills the lower portion of the wound. A new tip is thus provided for the nose, without the formation of scars on the forehead or the cheek.

Kolle's Method.—Kolle has obtained excellent results by making use of a flap from the forearm, on the inner side, just above the wrist, and grafted according to the Italian method. About the twelfth day the flap may be separated from the arm. At a later operation, when the free margin has healed, he forms the subseptum and sutures it to the stump, if any, or to a wound made to receive it.

For the restoration of a small defect in the tip of the nose, a flap without a pedicle may be taken from the ear (Koenig-Lexer).

CORRECTIVE NASAL PLASTICS

In contradistinction to the reparative and reconstructive operations upon the nose, corrective nasal plastics are applicable to noses which, without being actually defective, are a disfigurement and a constant source of annoyance because of their large size, unnatural position or unusual shape. As 3 different ways for improvement are possible, the corrective procedures may be divided into 3 corresponding divisions. Joseph proposes Greek designations for these corrective nose plastics, or rhinoplastics.

1. Rhinomiosis, the reduction of the nose in cases of hypertrophy or rhinomegaly.
2. Rhinothosis, the correction of the direction (obliquity) of the cartilaginous or bony nose.
3. Rhinometathesis, the transposition of nasal constituents for the correction of such nasal defects as saddle nose.

Intranasal correction of deformities of the nose has yielded favorable results at the hands of Joseph in Germany, and Molinie in France. Free access can be had to the entire bony framework of the nose without an external cicatrix. Moderate concavities of the dorsum of the nose are advantageously treated with paraffin injections. In more pronounced cases of saddle nose, protheses are required or transplantations of cartilage and bone. Aluminum, on account of its flexibility, can be readily shaped into the desired forms and dimensions. In the case of a man 20 years of age, a traumatic saddle nose, which had existed since infancy, was recently cured by Garrel and Gignoux by the insertion of a new nasal dorsum made from a spur of the septum, which was chiseled off and transferred through another intranasal incision into its new locality (8).

RHINOMIOSIS

As examples of rhinomiosis and rhinothosis, the descriptions of the 2 following cases by Joseph (14) may be taken.

Technic.—He divides his procedure into 3 steps:

FIRST STEP.—The skin and cartilages which will be superfluous for the new nose are removed, thereby making the opening of the nares smaller.

SECOND STEP.—All superfluous bony and cartilaginous portions of the nose are removed.

THIRD STEP.—The nasal septum is shortened in order to raise the tip of the nose.

RHINOTHOSIS

Technic.—FIRST STEP.—From the middle of the root of the nose 2 incisions are made forming an inverted V. In the upper portion the cuts go down to the bone, but in the lower portion they go through the entire thickness of the nose.

At the tip of the nose, 1½ cm. from the center, 2 other incisions are made, forming another inverted V within the first one, with its apex at a point on the middle line ½ cm. below the apex of the first.

SECOND STEP.—The skin in this area is removed and as much bone, septum and cartilage are chiseled away as is necessary to make a straight nose.

THIRD STEP.—A wedge-shaped piece from the cartilaginous and membranous septum is removed so as to raise the point of the nose.

FOURTH STEP.—The wound in the septum is sutured. The skin wound is then sutured, which results in an inverted Y-shaped scar.

RHINOMETATHESIS

Some of the various procedures for the correction of saddle nose follow:

Mechanical Appliances

Weir, in 10 cases, made use of an aluminum tripod, free in the nasal cavity. One end of the tripod is placed against the frontal bone, the other 2 are placed against the superior maxilla.

The objections, however, to mechanical appliances, is that they frequently cause ulcerations and necrosis of the bones from pressure.

Operative Procedures

Operative procedures are four-fold: The French method—cheek flaps; the Indian Method—forehead flaps; the finger method; transplantation of bone or cartilage.

Robert's Operation (27).—This is a good example of the cheek-flap method.

FIRST STEP.—A transverse incision is made in the groove at the bottom of the sunken region. This cut should go through the nasal cavity so as to free the lower portion of the nose, allowing the operator to draw down the tip and the alæ so that the tip is restored to its normal position and the nostrils are again in a horizontal plane.

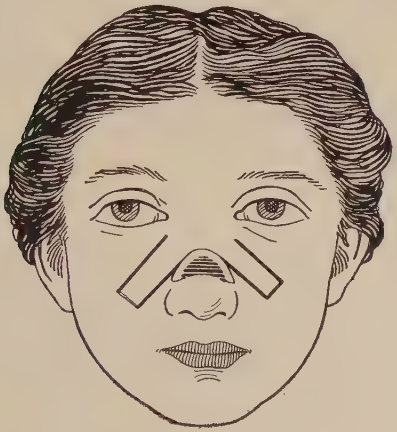

Fig. 29.—Robert's Operation, Showing Transverse Incision in the Groove at the Bottom of the Sunken Region and the Tip of the Nose Drawn Down, Also Outline of Flaps to be Taken from the Cheeks.

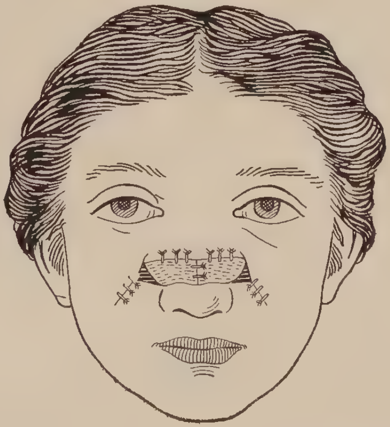

Fig. 30.—Robert's Operation, Showing the Flaps Taken from the Cheeks Turned Inward and Upward and Sutured with the Skin Surface Toward the Nasal Cavity.

SECOND STEP (Fig. 29).—A flap is taken from each cheek near the nasolabial fold and turned upward and inward and sutured together in such a manner that the skin surfaces are toward the nasal cavity. (Fig. 30.)

THIRD STEP.—After union is established, any irregularities at the base are corrected by incision and suture.

FOURTH STEP (Fig. 31).—An inverted V-shaped incision is made, beginning in the middle of the forehead, with its legs running downward and outward to points on the cheeks below the eyes. Just above the united flaps, a similar inverted V is made. In this second incision the legs are more widely separated than the first. The apices of these 2 inverted V's are connected by a vertical incision, thus forming 2 flaps.

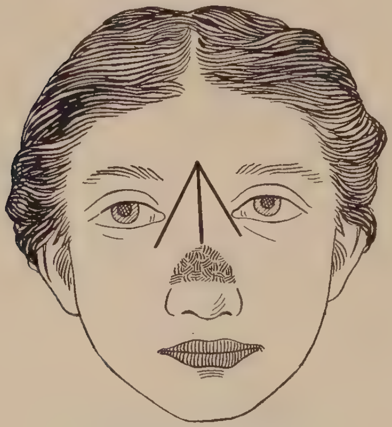

FIG. 31.—ROBERT'S OPERATION. Fourth step, showing formation of two flaps by V-shaped incisions.

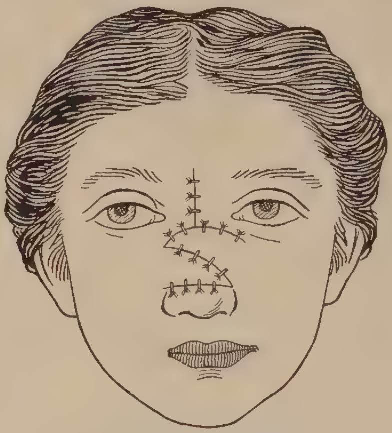

FIG. 32.—ROBERT'S OPERATION. Fifth step, flaps freed and rotated over cicatricial surface of reversed cheek flaps and sutured.

FIFTH STEP (Fig. 32).—These 2 flaps are then dissected from the underlying tissue and turned downward over the cicatricial surface of the reversed cheek flaps, so that the upper angle of the right flap is sutured to the base of the left ala, and that of the left flap is turned across the nose so as to reach a point near the inner canthus of the right eye.

The frontal wound is sutured in a vertical direction.

Koenig's Operation.—This is an example of the Indian method for the correction of saddle nose.

FIRST STEP.—A transverse incision is made at the deepest portion of the depression, making the soft parts of the nose movable, and the tip is brought down to its normal position.

SECOND STEP.—An osteoperiosteal skin flap, with its base at the root of the nose, is made in the forehead. The flap should be about 6 or 7 cm. long and 1 cm. wide. The bone is fractured at the root of the nose, and the flap is turned down and sutured to the lower edge of the opening. The raw surface of the flap is facing outward.

THIRD STEP.—A forehead skin flap, by the Indian method, is made to cover the raw surface and the apertures on both sides.

FOURTH STEP.—The forehead area may be covered by Thiersch grafts.

Israel's Modification of Koenig's Method (12).—This is an improvement on the original method, the skin forehead flap being done away with, which reduces the scarring very much.

FIRST STEP.—The cartilages and tip of the nose are separated from the sunken bridge by a transverse incision which allows the tip to resume its normal position.

SECOND STEP.—A skin-periosteal-bone flap is formed from the forehead. Israel uses a much narrower strip of bone—4 mm. wide—beginning, as in Koenig's operation, at the root of the nose and extending upward as far as necessary. The skin of the flap, however, should be about 2 cm. wide, so that it will almost entirely cover the raw surface of the strip of bone when the edges are brought together and sutured. When the skin has been sutured around the raw surface of the bone, the bone is fractured at the root of the nose, the flap is turned down (Fig. 33), skin side to nasal cavity, and its end is sutured to the tip.

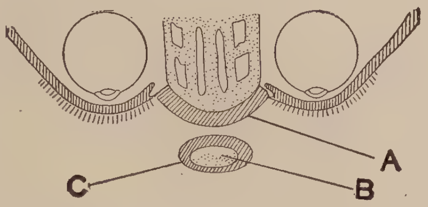

FIG. 33.—ISRAEL'S OPERATION, TRANSVERSE SECTION. A, Skin over bridge of nose. B, Periosteal-bone flap removed from forehead and turned down covered by C, skin from forehead.

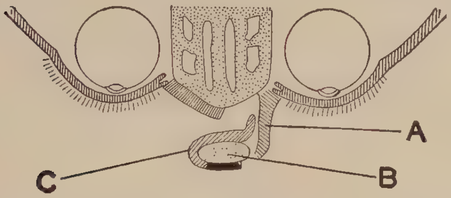

FIG. 34.—ISRAEL'S OPERATION, TRANSVERSE SECTION, SHOWING ON LEFT SIDE FORMATION OF FLAPS FROM TRANSPLANT AND BRIDGE OF NOSE.

THIRD STEP.—After several weeks the scar which has formed on the now anterior surface of the flap has contracted, and it is time for the second operation.

With a blunt hook, the transplanted bridge is drawn aside, and an incision is made in the median line through the skin of the old bridge of the nose; following this, 2 transverse incisions, 1 at the upper and 1 at the lower end of this vertical incision, are so made as to form 2 quadrilateral flaps. (Fig. 34.)

FOURTH STEP.—The blunt hook is removed, allowing the transplanted bridge to resume its normal position. A median incision is made down the center of the anterior surface of the transplant and at each end of this median

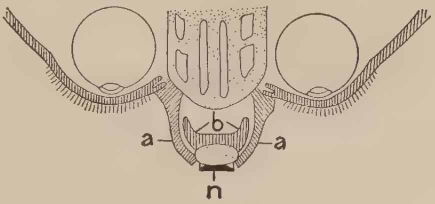

FIG. 35.—ISRAEL'S OPERATION, TRANSVERSE SECTION, SHOWING FINAL POSITION OF FLAPS RESULTING IN A SKIN LINING TO THE NOSE.

incision a transverse incision is made and 2 flaps so formed are reflected laterally. The 2 quadrilateral flaps are now brought over them so that their raw surfaces are in contact. (Fig. 35.)

FIFTH STEP.—Several weeks after the second operation, a third one is performed. The base of the pedicle is cut through at the root of the nose and deeply inserted, so that a natural sinking between the glabella and root of the nose is established.

Finney's Operation.—Finney's operation has brought forward the finger method (7).

FIRST STEP.—He removes the nail and matrix completely from the finger which is to be used, and denudes the dorsum of the finger up to the distal end of the first phalanx and also the entire circumference of the tip of the finger for a distance of about 1 cm. and stops all bleeding.

SECOND STEP.—In order to have no external scar, through an incision inside the nose, he carefully frees the skin over the defect from its attachments below. He then stretches the skin of the nose with a blunt instrument from the inside, in order to give as much room as possible for the new nose, and detaches the inner surface of the skin covering the nose, along its middle line, to a point well above the end of the bony structure.

THIRD STEP.—He next inserts the finger in the nose in such a manner that the tip comes in contact with the nasal process of the frontal bone, and the raw dorsal surface comes in contact with the denuded skin of the nose.

The finger is held in place with sutures, and plaster-of-Paris bandages are attached for 2 weeks.

FOURTH STEP.—He then disarticulates the metacarpophalangeal joint, and a few days later amputates the finger.

FIFTH STEP.—One week after this, he splits the tissues over the nasal spine of the superior maxilla, flexes the first phalanx to a right angle, and inserts the free end into the opening, thus forming the columna with the first phalanx.

SIXTH STEP.—Any minor operations necessary for cosmetic results he does under cocain.

Von Mangold's Operation (25).—This may be taken as a good example of the transplantation of cartilages.

FIRST STEP.—A transverse incision is made through the skin across the middle line at the glabella. With a Kocher sound or a blunt dissector, a tunnel is burrowed under the skin in the middle line down to the point of the nose.

SECOND STEP.—A piece of cartilage is excised from the seventh or eighth rib, 4 or 5 cm. long, 1 cm. wide, and ½ cm. thick.

THIRD STEP.—This piece of cartilage is pushed into the prepared tunnel with the side which has no perichondrium on it toward the skin, and the wound is closed over the glabella.

FOURTH STEP.—Through a small incision in each ala, a small tunnel is burrowed, and a thin piece of cartilage transplanted into each tunnel.

SECOND OPERATION.—Five months later an inverted V incision is made, the apex at the glabella and the legs running down each side of the nose. The soft structures of the nose are detached from the bone, and with them the cartilaginous graft. The upper end of the graft is sunk into the angle between the glabella and the root of the nose, thus restoring the normal depression.

Israel's Operation.—Israel (13), in a manner somewhat similar to the foregoing operation, transplants a strip of tibia under the skin of the nose to keep it straight.

Carter's Method.—Carter uses a piece of bony rib, which he inserts in a manner similar to von Mangold, except that he places the upper end of the graft in a periosteal pocket at the nasal process of the frontal bone.

Joseph's Method (15).—In order to have no outside wound, Joseph transplants a piece of tibia into a canal made through an opening in the mucous membrane of the nose.

ARTIFICIAL NOSES: PROTHESES

The preparation of an artificial nose requires the making of a plaster cast of the face which comprises at least a portion of the forehead, the eyes, the malar arches, and the nasal defect, including the upper lip, or, better, the entire mouth. From a clay model of a suitable nose, the artificial organ is then manufactured of rubber, celluloid, metal, porcelain, or wax; each of which has its advantages and disadvantages. The mode of fixation is of the greatest importance in the replacement of the nose, and may be accomplished in one of 3 ways: (1) Attachment of the prothesis to the frame of a pair of spectacles; the simplest but not the safest method; (2) attachment of the prothesis in the nostrils; (3) attachment of the prothesis to a denture made in the deeper parts. In cases where the pathological process has resulted in a communication between the buccal and nasal cavities, 1 or all 3 modes of fixation in combination may be used, according to the requirements of a given case.

When the nasal septum is lost, as sometimes happens as the consequence of neoplasms, especially sarcomata, a distressing deformity results even when the external contours of the nose are preserved. In these cases, a rubber support is inserted into the nasal cavity. A cast of the cavity is made by introducing one of the plastic substances used in dentistry through the nostrils, and, from the model thus obtained, a support is prepared of the desired shape and size, which is hollow, and open in front and behind, and supplied with a suitably modeled columna. After this rubber prothesis has been painted the proper color, it is introduced into the nasal cavity, where it is easily retained in place by the pressure of the surrounding soft parts. Some surprisingly good cosmetic results have been obtained by the use of this type of prothesis, and in cases where the loss of tissue is extensive it is much to be preferred to any attempt at operative restoration.

OPERATIONS ON THE MAXILLARY AND FRONTAL SINUSES

In operations on the sinuses, the exact etiology and diagnosis of the extent and character of the inflammation are necessary. Operations that can be done under local anesthesia are to be preferred. The purpose is to establish drainage and ventilation. Results depend largely on after-treatment.

The hemorrhage which inevitably occurs is always troublesome, but can be controlled by light packing and will usually stop within 24 hours.

Special instruments are required for most of the operations in this branch of surgery.

ANTRUM OF HIGHMORE OR MAXILLARY SINUS

In treating empyema of the antrum, the following points are of importance to determine the type of operation required to establish free drainage and ventilation:

1. Is the disease of dental or of nasal origin?
2. Is it acute or chronic?

The answers to these questions will determine which of the 2 types of entrance it is necessary to employ: the nasal or the extranasal entrance, either by way of the alveolar ridge or the radical operation, as described by Canfield-Ballenger or Cauldwell-Luc.

When the attack is acute and primary, if of dental origin, removal of the tooth and treatment of the trouble through the cavity with astringent irrigations will in most cases be all that is necessary. When the origin is nasal, to puncture the nasomaxillary wall through the nose with a trocar, and to follow this with irrigations, will usually be effective.

When the inflammation is chronic and severe, an opening may be made in the nasomaxillary wall large enough to insure its remaining open. But in extreme cases, and especially where the presence of polypoid growths is suspected, it will be necessary to perform one of the radical operations hereafter described.

Nasal Operation

Under local anesthesia, a large curved trocar is introduced into the nose. The point should be turned outward, touching the nasal wall of the antrum under the inferior turbinated bone, and steady pressure exerted on the trocar until it enters the antrum. The antrum may be irrigated through this opening, or it may be necessary to enlarge the opening with a biting forceps.

Part of the inferior turbinate may sometimes have to be removed to allow free drainage.

Nasal Operation of Vail.—This operation has the advantage of making a large opening in the naso-antral wall by means of the Vail saw, which is introduced into the nostril in the same manner as a trocar and which is so designed as to remove a circular or oval area.

The operation may be divided into 4 steps:

FIRST STEP.—By means of local application of cocain, the mucous membrane covering the naso-antral wall and the inferior turbinated bone is completely anesthetized.

SECOND STEP.—The anterior part of the inferior turbinated bone is removed with a curved scissors.

THIRD STEP.—The naso-antral wall is punctured at a low point with a Vail perforator.

FOURTH STEP.—The point of the Vail saw is introduced into the puncture, and the oval opening is made. The size of the hole can be regulated by the operator and should be large enough to allow for the granulations which have a tendency to close the hole.

The cavity of the antrum is lightly packed with a strip of gauze, which may be removed in 24 hours.

The process of repair is hastened and the tendency of the hole to close is diminished when there is a covering of mucous membrane over the inferior cut edge of the bone and the floor of the antrum. When such an aid to recovery would seem to be desirable, it must be taken into consideration before the third stage of the operation. A flap is formed of the mucous membrane covering the naso-antral wall, just below the inferior turbinated bone. Two vertical incisions are made downward from the extremities of the proposed opening, and the flap is lifted with its periosteum and turned out of the way until the operation is completed, when it is turned outward, covering the inferior raw bone surface and the freshened floor of the antrum.

Extranasal Operation

Alveolar Route.—This method is only applicable to conditions which are acute or of positively dental origin, or to chronic cases, as a preliminary only to a more extensive operation. The second bicuspid and first or second molar are in close relation to the floor of the sinus. If a tooth is suspected of being the etiological factor, the tooth must be removed, and, with a large drill, an opening made upward into the antrum. The antrum is irrigated through this opening and a tube inserted for drainage.

Radical Operation of Canfield-Ballenger (3).—This operation has given excellent results and seems to fulfill the claims made for it by Ballenger, who maintains "that this method of operation is (a) radical, inasmuch as it fully exposes the cavity of the antrum to inspection and treatment; (b) it is conservative, as it is attended by the least possible destruction of physiological structures, particularly the inferior turbinal, which is neither temporarily nor permanently resected; (c) furthermore, the operation may be done under local anesthesia, whereas other operations equally radical (and more destructive) must be done under general anesthesia; (d) the time required for this operation is much less than that for other radical operations."

The operation consists in the removal of that portion of the naso-antral wall lying between the attachment of the inferior turbinated body and the floor of the nose, plus that portion lying anteriorly to the anterior end of the inferior turbinated body (Fig. 39).

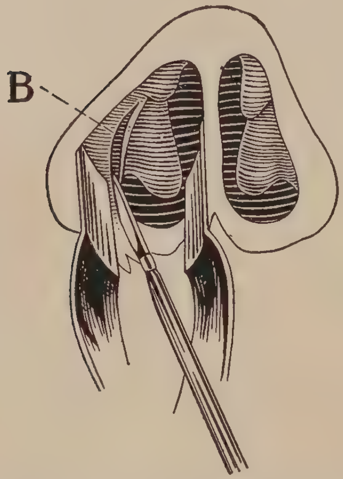

Fig. 36.—Canfield-Ballenger Operation, Showing Incision in Naso-antral Angle Down to Bone.

The operation progresses in 4 steps:

FIRST STEP.—The nasal mucous membrane is rendered anesthetic by the direct application of cocain. The skin surrounding the mucocutaneous junction is anesthetized by the injection of Schleich's solution, as well as the deeper parts. It is also necessary to inject the periosteum overlying the canine fossa.

SECOND STEP.—A nasal speculum is introduced and the ala of the nose distended, exposing the naso-antral wall. An incision is then made, the whole length of the naso-antral angle, down to the bone (Fig. 36). With a periosteal elevator the soft parts over the canine fossa are lifted. The resulting bleeding is easily controlled by pressure.

THIRD STEP.—With a rongeur forceps or a gouge, an opening is made into the antrum through the naso-antral angle (Fig. 37). This opening, at its posterior border, must be below the inferior turbinate.

FOURTH STEP.—A Wagener forceps is used to remove that portion of the naso-antral wall lying between the attachment of the inferior turbinate and the floor of the nose and also a small area anterior to the anterior end of the inferior turbinate (Figs. 38 and 39). If this opening does not prove large enough to expose the entire mucous membrane, it may be enlarged by removing some of the bone of the canine fossa.

Unless the mucous membrane is found to be covered with masses of granulations or polypi, curettage should be avoided and the condition treated with astringent solutions.

AFTER-TREATMENT.—After the operation the cavity is packed lightly with sterile gauze and the dressings changed daily. After 3 or 4 days, the gauze dressings may be discontinued and the cavity kept clean by swabbing or spraying several times a day with a cleansing or stimulating solution.

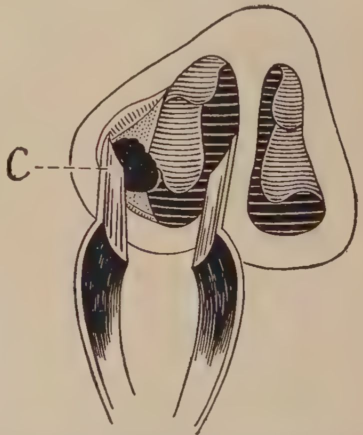

Fig. 37.—Canfield-Ballenger Operation, Showing Opening Made into Antrum.

Radical Operation of Cauldwell-Luc (6).—This operation requires a general anesthesia. The antrum is entered by way of the canine fossa. The cavity of the nose is entered in such a way as to destroy a large portion of the naso-antral wall including the inferior turbinated bone. It gives, however, excellent drainage, but may be considered unnecessarily mutilating.

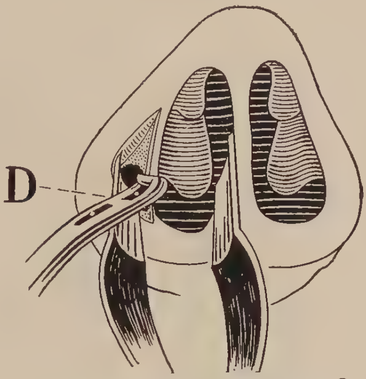

Fig. 38.—Canfield-Ballenger Operation, Showing Removal of Naso-antral Wall. D, Naso-antral wall being covered with the Wagener forceps.

FIRST STEP.—The cheek and mouth are packed—the cheek to keep the saliva out of the wound, and the mouth to keep the patient from swallowing blood.

SECOND STEP.—The gingivolabial fold is incised from the second incisor to the first molar, through the mucous membrane and periosteum. The incision is made high enough to leave sufficient mucous membrane on the tooth side for suture.

THIRD STEP.—The periosteum is elevated above the incision.

FOURTH STEP.—The wall of the canine fossa is broken through with a gouge, in a backward and outward direction. This opening is made large enough to readily admit a finger.

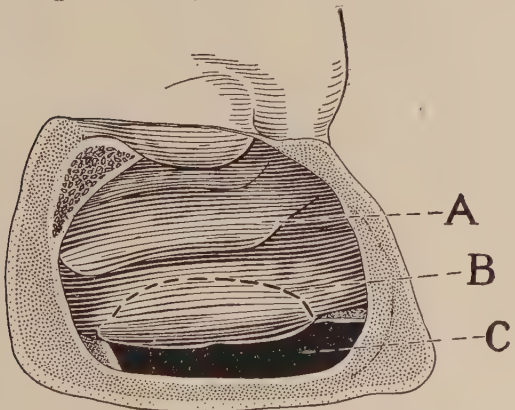

Fig. 39.—Canfield-Ballenger Operation, Lateral View, Showing Removal of Naso-antral Wall Below the Attachment of the Inferior Turbinated Body. A, The middle turbinate. B, Line of attachment of inferior turbinate which is left intact. C, Naso-antral wall removed extending from the floor of the nose to the attachment of the inferior turbinate and from the anterior to the posterior limits of the antrum.

FIFTH STEP.—All granulation tissue in the cavity of the antrum is curetted away and all necrotic bone.

SIXTH STEP.—The mesial wall of the antrum is curetted away so that the nasal cavity and antrum are one. The antral wall is scraped away until it is at a level with the floor of the nasal chamber. A light packing of gauze is put in the antrum, with one end emerging from the nostril.

SEVENTH STEP.—The gingivolabial fold is sutured with catgut.

AFTER-TREATMENT.—Fluid diet is necessary. No movement of the mouth should be allowed, in order to insure perfect union of the gingivolabial fold. The gauze may be removed in 24 hours.

FRONTAL SINUS

Operations upon the frontal sinus are dangerous, and, to insure safety and good results, it is essential to have an accurate knowledge of the region, which is only acquired by study of specimens and dissection.

No frontal sinus operation should be undertaken without the aid of X-ray photographs, because of the enormous individual variations in the size and shape and situation of the sinuses. Both lateral and anteroposterior views are essential. Special instruments are required.

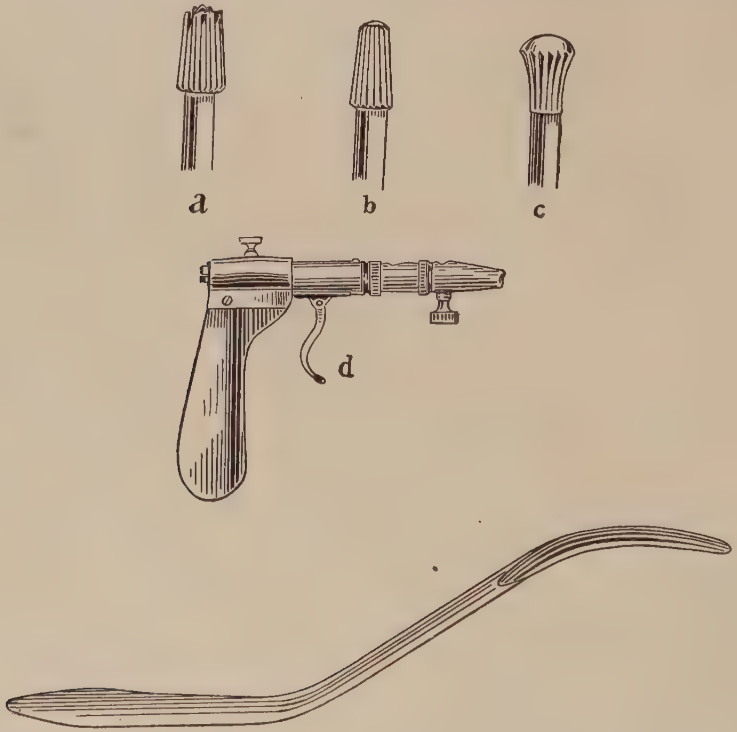

Fig. 40.—Halle's Instruments: Guide and Protector and Graduated Hand-drills.

The principal danger to be guarded against is the perforation of the internal plate of the frontal bone, through which the septic material in the sinus may penetrate to the meninges and brain.

There are 2 methods of entrance: The intranasal operations and the extranasal.

The intranasal operations are somewhat more dangerous than the extranasal, because of the distance of the operative field and its smallness; and they are less effective because the inflammation subsides more slowly since the drainage is not as free. Their one advantage, however, is that they do not leave a deformity.

The extranasal operations give complete access to the cavity, allow the whole inflammatory area to be seen, and facilitate the rapid subsidence of the inflammation.

INTRANASAL OPERATIONS

Halle's Method (35).—Special instruments have been designed by Halle to enter the frontal sinus: a guide and protector which he inserts into the sinus by way of the frontonasal canal, and graduated hand-drills (Fig. 40). The operation is done in 3 steps.

FIRST STEP.—Local anesthesia is produced by cocain and adrenalin. A probe is introduced into the sinus by way of the frontonasal canal, for the distance of about 3 cm. The protector is introduced beside the probe for the same distance, and the probe is removed.

SECOND STEP.—Just anterior to the protector, which is designed to prevent injury to the internal plate of the frontal bone, the small pointed drill is introduced, and a hole made large enough for the end of the small, blunt drill to engage; with it the size of the hole is enlarged to take the next instrument (Fig. 41).

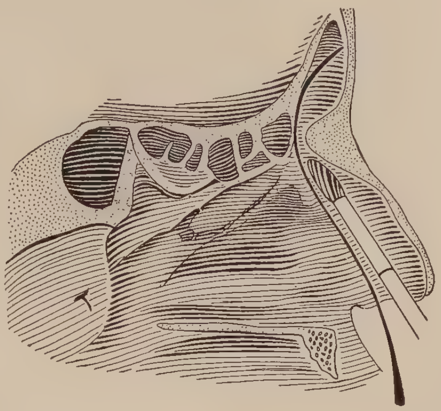

FIG. 41.—SHOWING INTRODUCTION OF PROTECTOR AND DRILL IN THE NASOFRONTAL CANAL.

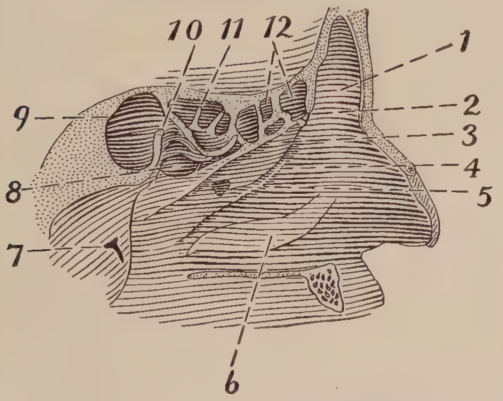

FIG. 42.—FLOOR OF THE FRONTAL SINUS REMOVED. 1, Frontal sinus; 2, nasofrontal canal; 3, bulla ethmoid; 4, hiatus semiluna; 5, proc. nucin; 6, concha interior; 7, tuba eust.; 8, meat. sup.; 9, sinus sphygmoid; 10, rec. sphano. ethmoid; 11, cell. ethmoid. post.; 12, cell. ethmoid. ant.

THIRD STEP.—The blunt drill is to be withdrawn and the pear-shaped drill inserted. With this, all of the floor of the sinus is demolished, thus exposing the mucous membrane for treatment.

AFTER-TREATMENT.—The sinus is packed with iodoform gauze, and granulations are retarded with silver nitrate.

Good's Method.—This operation is similar to the foregoing one except that, instead of drills, a specially constructed rasp is used to demolish the floor of the sinus and a portion of the middle turbinate bone is removed (36).

FIRST STEP.—The anterior portion of the middle turbinate bone is removed.

SECOND STEP.—A frontal sinus probe is introduced into the frontonasal canal and then the guard and guide (Fig. 43), which has the same curve as the probe and is introduced in the same way. If there is the slightest reason to believe that the probe has not entered the sinus by way of the frontonasal canal, this operation should be abandoned.

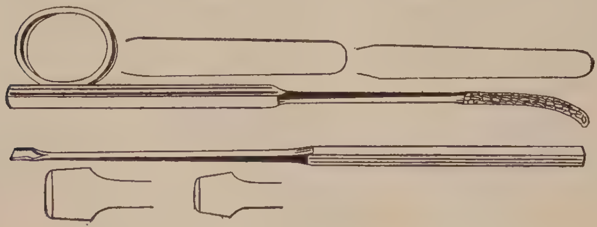

FIG. 43.—GOOD'S OPERATION: RASP AND GUARD.

THIRD STEP.—The frontal sinus rasp is introduced into the frontonasal canal in front of the guard. Some force is necessary, as a few ethmoidal cells along the side of the canal must be crushed, as well as some of the floor of the frontal sinus. In this way the communication is enlarged between the nose and the frontal sinus.

AFTER-TREATMENT.—The frontal sinus is irrigated with boric acid solution and exuberant granulations kept down.

EXTRANASAL OPERATIONS

Killian's Method (17).—Up to the present time this operation has given by far the best results. Briefly it consists in removing the anterior wall and the floor of the sinus through an opening following the outline of the eyebrow and curving around the side of the nose. Its one disadvantage is the deformity it causes, which is especially marked in cases with either very high or very deep sinuses. The procedure is divided into 11 steps.

Before beginning the operation, Killian gives the patient a small dose of morphin subcutaneously. The eyebrow is shaved, and the nasal cavity is flushed. In case the maxillary sinus is discharging pus, it is also flushed.

FIRST STEP.—The skin incision begins at the temporal end of the eyebrow, is carried through the eyebrow to its inner end, curves downward and outward at the root of the nose, and ends somewhat below the base of the nasal bone. The incision goes down to the periosteum, and the operator guards the supraorbital margin with his left hand. (Fig. 44.)

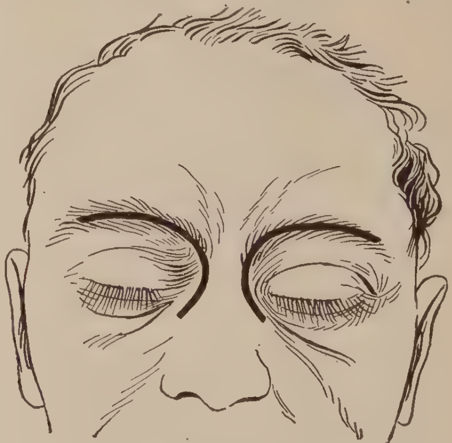

FIG. 44.—KILLIAN'S OPERATION, SHOWING SKIN INCISIONS.

SECOND STEP.—Two incisions of periosteum are made. The upper one is 5 to 6 mm. above and parallel to the supra-orbital margin, its inner end reaching the suture line at the upper end of the nasal bones. The lower one corresponds with the skin incision, running along the supra-orbital margin.

THIRD STEP: OPENING OF THE SINUS.—Above the upper incision, the periosteum is scraped away, leaving untouched the periosteum over the superciliary ridge. The bone is carefully removed with a chisel, avoiding injury to the mucous membrane. A probe is carefully passed between the mucous membrane and the bone, to measure the extent of the sinus. The mucous membrane must not be injured.

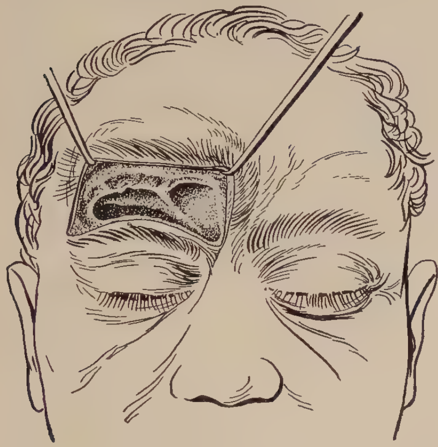

FIG. 45.—KILLIAN'S OPERATION, SHOWING REMOVAL OF THE ANTERIOR WALL OF THE FRONTAL SINUS LEAVING THE SUPRA-ORBITAL RIDGE INTACT.

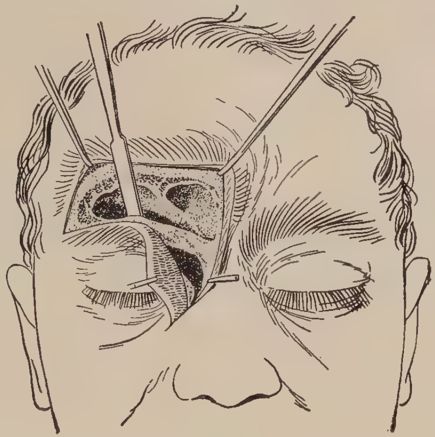

FIG. 46.—KILLIAN'S OPERATION, SHOWING THE REMOVAL OF THE FLOOR OF THE FRONTAL SINUS AND THE FRONTAL PROCESS OF THE SUPERIOR MAXILLA.

FOURTH STEP: EXCISION OF THE FRONT WALL.—After determining the extent of the sinus, the bone along the upper periosteal incision is chiseled away down to the mucous membrane and to the outer extremity of the sinus. The anterior wall of the sinus is then chiseled or bitten away with a bone forceps, avoiding the supraorbital ridge. (Fig. 45.)

FIFTH STEP.—All granulations and the mucous membrane are thoroughly curetted away, breaking down any bony septa which may occur and getting a free and thorough inspection of the sinus.

SIXTH STEP: REMOVAL OF THE FLOOR OF THE SINUS.—Standing behind the patient, with a good light shining into the wound, an opening is made with a chisel in the floor of the sinus, carefully avoiding injury to the supraorbital arch of the bone. When the opening is made, the rest of the floor is removed with a bone forceps. (Fig. 46.)

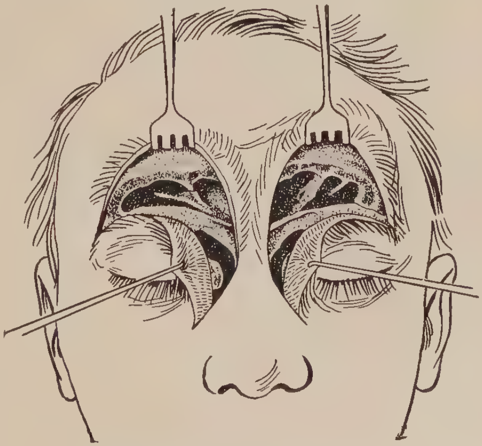

FIG. 47.—KILLIAN'S OPERATION, SHOWING COMPLETE OPENING OF BOTH FRONTAL SINUSES.

SEVENTH STEP: REMOVAL OF THE FRONTAL PROCESS OF THE SUPERIOR MAXILLA AND THE REMAINING PORTION OF THE FLOOR OF THE SINUS. —Taking great care not to injure the nasal membrane, the frontal process is trephined and the exposed bone is removed with a slender bone forceps. A chisel may have to be used to enter the upper and inner corner of the eye, which has a dense structure. With this addition to the opening, the deeper parts of the sinus floor, the floor and walls of the temporal and orbital recesses of the frontal sinus and the orbital recesses of the ethmoid cells are easily removed. (Fig. 47.)

EIGHTH STEP.—The anterior and the middle ethmoid cells and the corresponding parts of the middle turbinate are excised in order to have a cavity which is perfectly even and smooth.

NINTH STEP: FORMATION OF A FLAP CONSISTING OF UNINJURED NASAL MUCOUS MEMBRANE.—The nasal mucous membrane is perforated at the edge of the nasal bone, and an incision made in an upward and backward direction to about ½ cm. below the cribriform plate, from which point it continues downward. The flap thus formed is turned outward to cover those parts of the wound facing the nasal cavity, thus securing a permanent wide communication between the nasal and frontal cavities.

TENTH STEP.—The wound is irrigated with salt solution and dusted with iodoform. A drainage tube is inserted at the temporal end of the incision and carried through the external nasal orifice. A nasal plug keeps the tube and flap of mucous membrane in place.

ELEVENTH STEP.—The edges of the wound are carefully sutured.

AFTER-TREATMENT.—The patient is made to lie on his healthy side. He must not be allowed to blow his nose, but must aspirate all secretions. The dressings are changed daily. The plug is removed on the second day, the tube on the third or fourth day, and the sutures on the fifth day. Continue the dressings for some time longer, and in no case flush the wound.

Any granulations arising within the nose are removed with strong $AGNO_3$, Sol. 2½ gr. to oz. Killian finds that the external wound heals in 10 days, and he keeps his patient in the hospital for a fortnight.

A. Knapp's Method (18).—The essential point of this operation is that the frontal sinus is attacked through the floor of the sinus *via* the orbit. It has given excellent results and makes no scar in the forehead. **It is, however, a very difficult operation.**

FIRST STEP.—The skin incision is made along the upper orbital border midway between the eyebrows and the bony orbital margin, then down along the inner wall and the side of the nose to the floor of the orbit. Knapp prefers this incision to the Killian, for, if necessary, external drainage may be instituted and he does not pack the nose.

SECOND STEP: INCISION OF THE PERIOSTEUM.—The periosteum is incised just at the orbital margin above and in a line with the cutaneous incision along the nose, and retracted with a sharp retractor. "After the firm adhesion of the periosteum to the orbital margin is separated, the soft parts with the orbital contents and the lacrimal sac are gently detached and free access is given to the roof and to the inner wall of the orbit. The pulley of the superior oblique is carefully detached from the trochlear fossa by a blunt periosteotome working from behind forward."

THIRD STEP.—The floor of the frontal sinus is removed with a chisel and hammer and the mucous membrane curetted, breaking down all septa. The nasal process of the superior maxilla is resected as well as the lacrimal, and the ethmoid bones, thus getting free access to the middle fossa of the nose. The ethmoidal labyrinth is completely removed with a curet.

FOURTH STEP.—If the highest point in the frontal sinus cannot be reached from below, the skin is retracted forcibly and an opening made in the anterior bony wall.

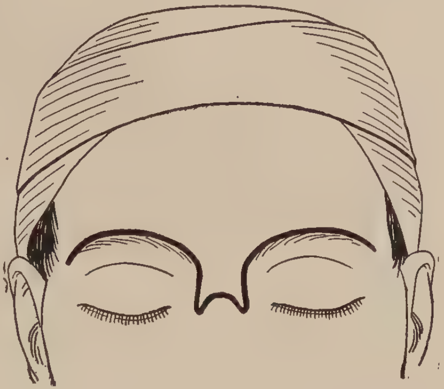

FIG. 48.—BECK'S OPERATION, SHOWING INCISION THROUGH SKIN AND SUBCUTANEOUS TISSUE THROUGH THE UPPER MARGIN OF THE EYEBROWS.

FIFTH STEP.—Suture of the skin wound is not necessary. The edges approximate themselves. A wick of gauze is inserted into the frontal sinus through the external wound at the nasal angle.

Beck's Double Osteoplastic Flap Method (5).—In this operation the bone of the anterior walls of the sinuses is used as a flap, hinged at its lower border, which, after the cavity has been cleaned, is replaced in its former position. This method has the great advantage of leaving no deformity of depression such as occurs after each other extranasal operation on the frontal sinus.

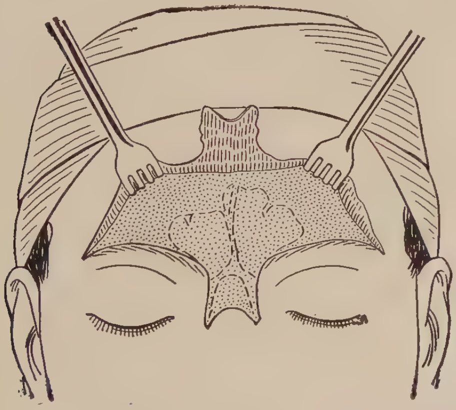

FIG. 49.—BECK'S OPERATION, SHOWING THE DISSECTION ON THE FLAP UPWARD.

FIRST STEP: PREPARATION OF A CELLULOID TRACING OF THE FRONTAL SINUS.—A piece of celluloid film about 3 in. square is placed over the X-ray plate in the trans-illuminating box. The outlines of the sinuses, as well as the supra-orbital margins are made upon the celluloid, and an exact pattern is cut out which is sterilized in bichlorid and alcohol.

SECOND STEP: THE SKIN INCISION.—The skin and subcutaneous tissue are incised through both eyebrows. The incisions arch downward and are joined by a transverse incision across the bridge of the nose (Fig. 48).

THIRD STEP.—The skin flap is dissected upward far enough to allow the upper limit of the frontal sinuses to be exposed, using the celluloid pattern to determine the upper limit (Fig. 49).

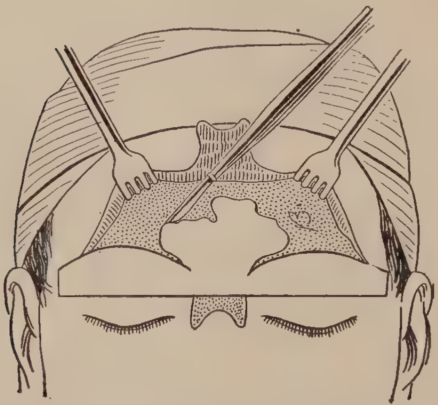

FIG. 50.—BECK'S OPERATION. Method of placing the celluloid tracing over the frontal sinuses.

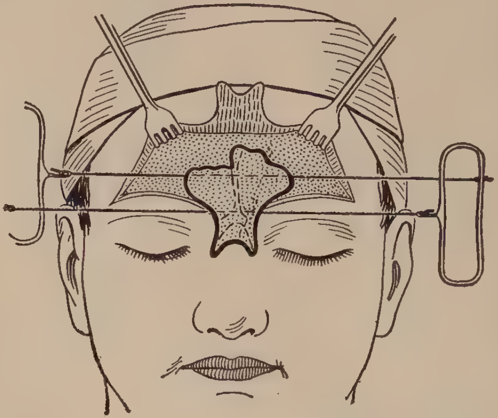

FIG. 51.—BECK'S OPERATION. Cutting the inferior border of the bone flap with a Gigli saw from within outward.

FOURTH STEP.—The celluloid plate is placed in position over the frontal region, and the periosteum is incised around the plate over the upper and lateral margins of the sinuses—but not over the supra-orbital borders—leaving the inferior borders of the sinuses to be used as the hinge for the flap. (Fig. 50.)

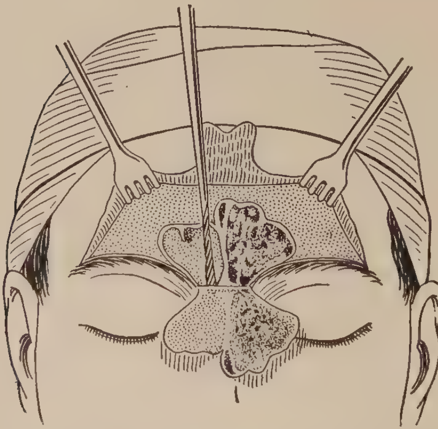

FIG. 52.—BECK'S OPERATION, SHOWING THE RIGHT SIDE WITH THE GRANULATIONS REMOVED AND THE DRILL IN OPERATION ENLARGING THE NASOFRONTAL OPENING. The left side shows the cavity filled with granulations and pus.

FIFTH STEP.—Following the outline of the periosteal incision, a chisel is used to cut through the bone, which is slightly beveled.

SIXTH STEP.—The bone is pried out, and the inferior border of the bone flap is cut from the inside with a Gigli saw, through almost its entire thickness, taking care to leave the periosteum intact so that it will not be broken when the bone flap is turned down over the nose. (Fig. 51.)

SEVENTH STEP.—The sinus is now exposed. The disease is thoroughly eradicated, but the mucous membrane is not curetted. The frontonasal canal is enlarged with a Halle trephine or a Good rasp (Fig. 52). The anterior ethmoidal cells are removed.

EIGHTH STEP.—Drainage is introduced through the nasofrontal canal.

NINTH STEP.—The osteoplastic flap is replaced and the skin sutured.

AFTER-TREATMENT.—The next day the gauze is removed and a gold filigree tube inserted. In one case only Beck inserted no tube, and the canal remained patent. Douches should be avoided.

If, during convalescence, it is found that the drainage is insufficient, it is a simple matter, under local anesthesia, to re-open the skin wound, remove the bone flap and thus establish external drainage.

Kuhnt's Method.—This operation consists in the total removal of the anterior wall of the frontal sinus, with a chisel and bone forceps, followed by the thorough curettage of the contents of the cavity without interfering in any way with the lumen of the nasofrontal canal. The cavity is packed, and the entire wound is left open and allowed to heal by granulations from the bottom, until the cavity is obliterated. The external wound is not sutured.

This procedure takes excessively long to heal, and the scar is disfiguring. It does not include the cleaning out of the ethmoidal cells, which are usually involved and may prevent a cure. The motor function of the eye has been known to be disturbed by an extension of the inflammation.

Hajek-Luc Method.—FIRST STEP.—The incision begins at the temporal end of the eyebrow and follows the line of it to the bridge of the nose. From there a second incision starts and extends upward as far as the upper limit of the frontal sinus. With this triangular-shaped incision the skin and the periosteum may be turned up and the frontal plate exposed.

SECOND STEP.—A portion of the exposed bone is chiseled away, opening the sinus to inspection and curettage.

THIRD STEP.—After determining the extent of the cavity, the inflammatory tissue is scraped out and any bony septa are broken down. The nasofrontal canal is enlarged as much as possible, and the anterior ethmoidal cells broken down with a curet.

FOURTH STEP.—A large rubber tube is inserted into the enlarged nasofrontal canal and left there for several weeks.

The external wound is closed and allowed to heal by primary intention.

ADVANTAGES AND DISADVANTAGES.—Ballenger (2) comments on this procedure as follows:

> "ADVANTAGES OF THE OPERATION.—The advantages of this method of operating are: (1) It avoids disfigurement, as the wound heals by primary intention; (2) the frontonasal canal is enlarged, the anterior ethmoidal cells eradicated; and (3) as they are invariably involved in frontal sinusitis, this operation is advantageous, because they are opened and drained in its performance.
>
> "DISADVANTAGES OF THE OPERATION.—Relapse occurs in about 50 per cent. of the cases, because the curettement cannot be done thoroughly, as the ethmoidal cells are not accessible through the frontal wound. Suppuration of the scalp has been reported and the operation has been followed by sinusitis on the opposite side. Severe intracranial complications have been reported. . . . It appears, therefore, that this method, while apparently very simple, is sometimes followed by very serious sequelæ. In view of these facts, it is usually better to adopt Kuhnt's operation, or at least a combination of the two."

These last 2 operations, the Kuhnt and the Hajek-Luc, are well known and widely practiced, and are given here for comparison, although they have been superseded by the more modern ones which precede them. These more extensive operations have all the advantages, enumerated by Ballenger, of the Hajek-Luc method, and they minimize the disadvantages.

I strongly recommend the employment, where possible, of the more radical operations; not only because of the increased probability of a cure, but also because the period of convalescence is shortened and the possibility of fatal or even serious complications is diminished.

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SURGERY OF THE MOUTH, TONGUE, SALIVARY GLANDS AND PHARYNX

CHAPTER V

SURGERY OF THE MOUTH, TONGUE, SALIVARY GLANDS AND PHARYNX

FORBES HAWKES

DIAGNOSIS OF OPERABLE CONDITIONS OF THE MOUTH, TONGUE, SALIVARY GLANDS, AND PHARYNX

Instruments.—The instruments used in the diagnosis of operable conditions of the mouth, salivary glands, tongue, and pharynx are:

LIGHT.—Direct sunlight, when available, is to be preferred to any of the artificial lights. The convenience of the small electric light bulb, which may be used either as a headlight or as a light which can be moved about in the patient's mouth, so that the various recesses are directly illuminated, has brought this light into general favor. The street current may be used with these lamps, by the interposition of a rheostat, for examination in the patient's home. Small, portable, pocket light batteries will also supply the necessary current. With a good headlight, and with the help of a cheek retractor and a tongue depressor, all the oral surfaces can be thoroughly inspected. (Fig. 1.)

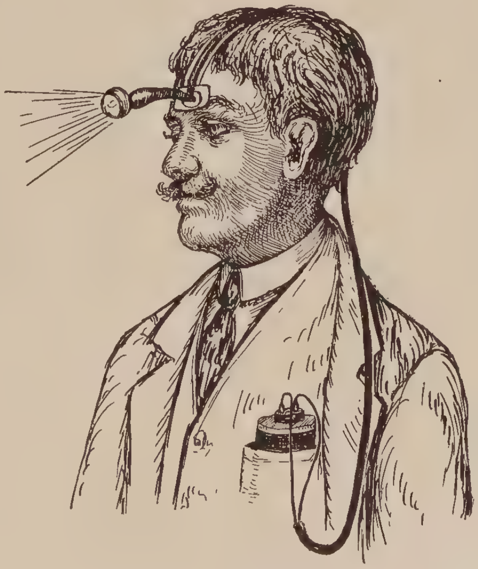


FIG. 1.—PORTABLE HEADLIGHT AND BATTERY.

MOUTH GAG.—For the examination of adults, a mouth gag is not usually necessary. In children one is often serviceable. Here the least formidable one is the best. A cork of moderate size answers the purpose exceedingly well, and is not a disagreeable object for the child to bite. A string, however, should always be attached to the cork to prevent the child from swallowing it during the struggles which may follow the attempt at examination. For routine office examination, either a piece of soft white wood, about 1 in. square, which can be sterilized by dipping in boiling water, or one of the firm rubber gags which are guttered on 4 sides, may be used. A string should always be attached to a mouth gag of this kind. To forcibly open a child's mouth without inflicting injury to the teeth or gums is at times a difficult matter. With a little patience on the part of the examiner, a favorable time will occur, as when the child begins to cry, and a cork or rubber gag may then be introduced. This is followed by a Gross gag, with the jaws protected by soft rubber tubing. The jaws of the gag are slowly separated, while the head is kept as still as possible by the assistant. (Figs. 2 and 3.)

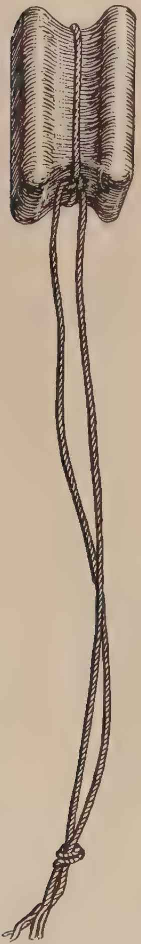


Fig. 2.—Rubber Gag.

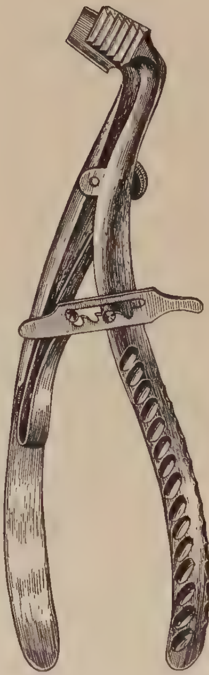


Fig. 3.—Gross Mouth Gag.

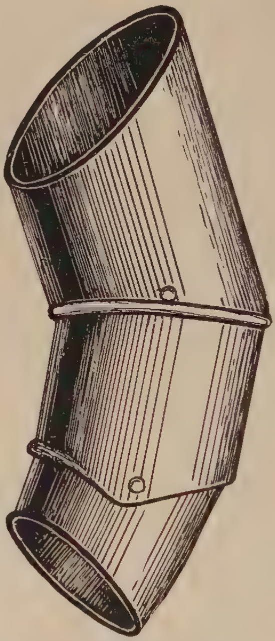


Fig. 4.—Metal Finger Protector.

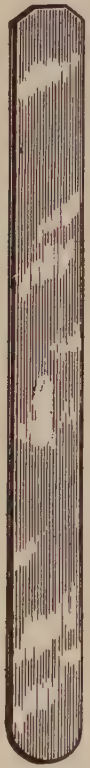


Fig. 5.—Plain Wood Tongue Depressor.

METAL FINGER PROTECTORS may be used, if desired, in the case of children. (Fig. 4.)

FINE SILVER PROBES WITH BLUNT ENDS are used in sounding the ducts of the salivary glands. For the parotid duct, a slender probe curved to about 45° at ½ in. from its tip, conforming to the direction of the duct, is of advantage when sounding the distal inch of the tube.

A SLENDER FLEXIBLE WHALEBONE GUIDE may occasionally be introduced all the way up the duct to the gland. Foreign bodies may be detected by these guides. It is, however, at times impossible to get any guide or probe all the way up the duct, and its caliber must be roughly judged by the salivary outflow as seen.

Routine Examination of the Mouth and Pharynx.—The teeth and gums are inspected, the color and condition of the edge of the gums being especially noted.

The floor of the mouth anterior to the tongue and the openings of the salivary ducts that are there present are inspected, together with the condition of the frenum.

The flow of saliva is observed.

The shape and surface appearance of the tongue as far back as the large papillæ are noted.

With the tongue depressor the tongue is pushed over to either side, and the sulcus between the tongue and the horizontal ramus of the jaw is inspected.

The cheek retractor is inserted, and the buccal surface of either cheek is examined.

The orifices of the parotid ducts are sought for and their salivary outflow observed.

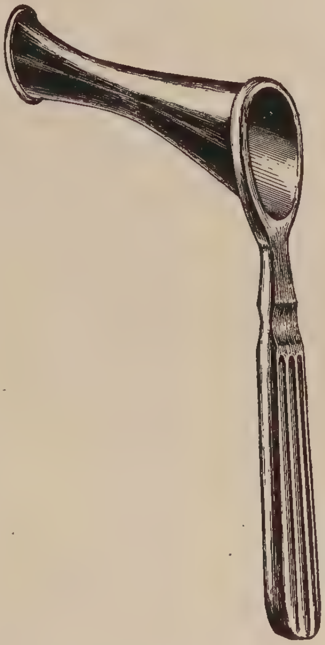


FIG. 6.—YANKAUER'S PHARYNGEAL SPECULUM.

The surface appearance of the pharyngeal membranes, as seen through the mouth, is noted, together with the condition of the tonsils, of the soft palate, and of the roof of the mouth.

The tip of the tongue is grasped with a small clean napkin, and light traction exerted on it, bringing the posterior part of the upper surface of the tongue into view.

The index finger, over which a fresh thin rubber cot has been drawn, is then introduced and all surfaces palpated.

It is of distinct help to have the other hand exert light counter pressure outside, against the soft tissue, when examining the floor of the mouth, the sublingual and submaxillary regions, the tongue and the mucous membrane of the cheek.

The pharynx may also be examined by means of the pharyngoscope (either the direct image or inverted image pharyngoscope).

Yankauer's pharyngeal speculum is of distinct advantage in examining the upper part of the pharynx. (Fig. 6.)

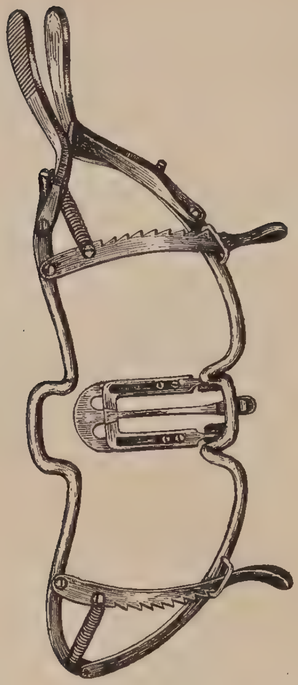


Fig. 7.—Whitehead's Mouth Gag.

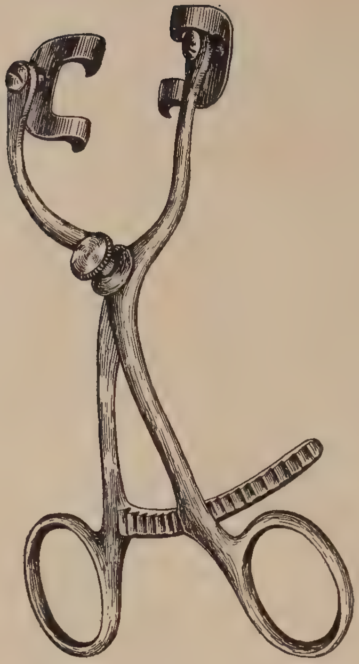
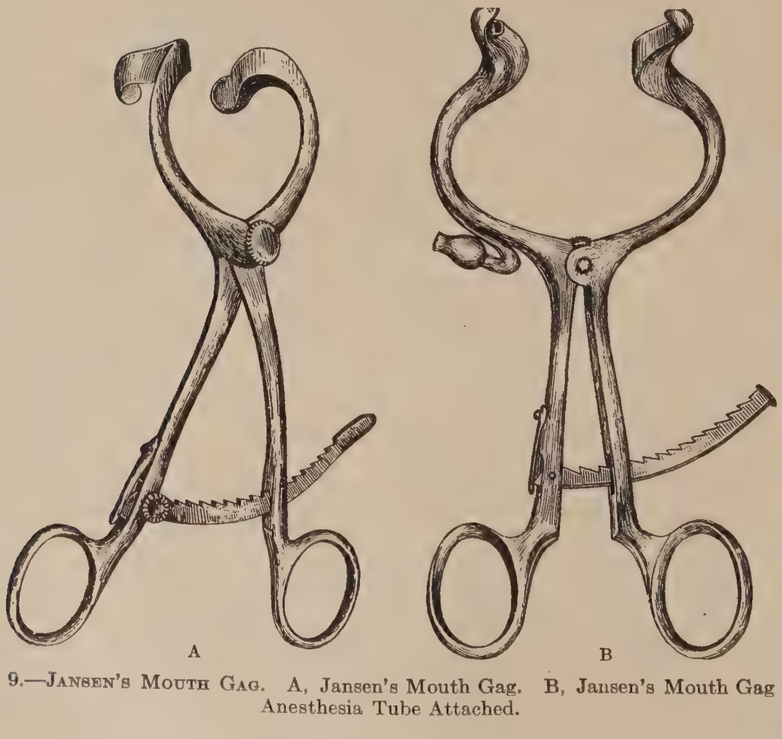


Fig. 8.—Collins' Mouth Gag.



A

B

Fig. 9.—Jansen's Mouth Gag. A, Jansen's Mouth Gag. B, Jansen's Mouth Gag with Anesthesia Tube Attached.

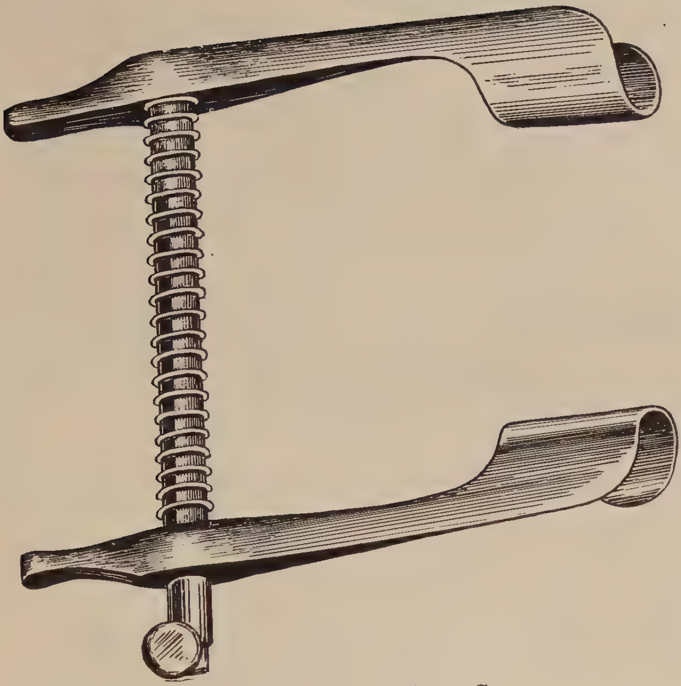


Fig. 10.—Murdoch's Mouth Gag.

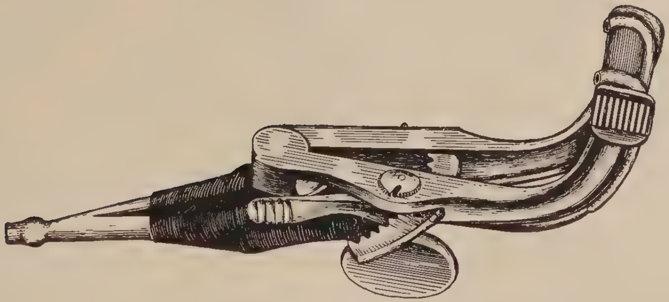


Fig. 11.—Gwathmey-Ferguson's Mouth Gag.

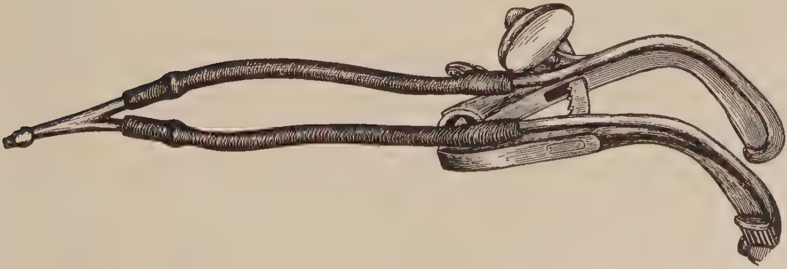


Fig. 12.—Gwathmey-Ferguson's Mouth Gag with Anesthesia Tube Attached.

SPECIAL INSTRUMENTS USED IN OPERATIONS ON THE TONGUE, SALIVARY GLANDS, THE FLOOR OF THE MOUTH AND PHARYNX

Mouth Openers.—Gross's, Roser's, Koenig's or Hister's mouth openers can be inserted, preferably between sound teeth (bicuspids or molars if possible), and sufficient opening secured so that a mouth gag can be adjusted. The routine use of hard screws or wedges is inadvisable; they are likely to cause fracture of one or more teeth.

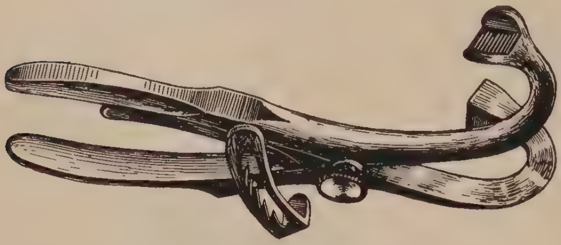


Fig. 13.—Denhart's Mouth Gag.

Mouth Gags.—The operator will be governed in the selection of a gag by the following considerations:

a. The part of the mouth which is to be operated upon.

b. The conditions of corresponding teeth, i. e. their strength to resist the force necessary to secure a sufficient oral aperture. The presence of loose teeth or of bridge work may determine in great measure where the force had best be applied.

c. Where teeth are missing, the condition of the gums at various points.

The handles of mouth gags used during operations should as a general rule be out of the operator's way, and there should be no bars or cross pieces to interfere with the free movement of all instruments. The following are among the most useful mouth gags for these purposes:

Whitehead's, of various sizes, and with various attachments, such as tongue depressors and uvula retractors. (Fig. 7.)

Collins', with or without tongue depressor. (Fig. 8.)

Jansen's, with anesthesia tube attached. (Fig. 9.)

Murdoch's. (Fig. 10.)

Gwathmey-Ferguson's, with anesthesia tube attached. (Figs. 11 and 12.)

Denhart's. (Fig. 13.)

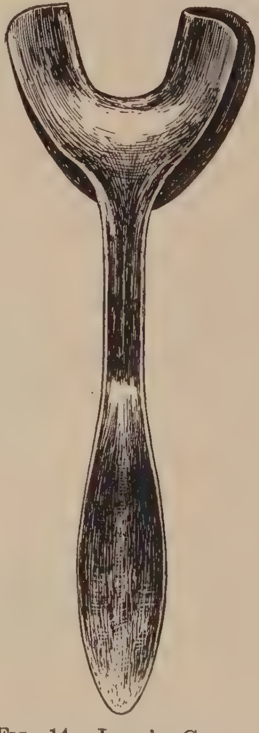


Fig. 14.—Luer's Cheek Retractor.

It is usually best to open the mouth to the required extent with one of the mouth openers that is provided with flat jaws, so as to distribute the pressure as evenly as possible, and then to insert the mouth gag that seems best suited to the proposed operation. The jaws of most of the mouth gags that are made at present are provided with flat or corrugated pieces of lead where they come in contact with the teeth, in order to diminish the likelihood of chipping or breaking away portions of them. Short pieces of rubber tubing may be slipped over the jaws so as to guard still more against slipping.

Tongue Depressors.—Of the various tongue depressors, those that have offset handles are least in the operator's way (Tuerck's right- and left-handed). (Fig. 15.)

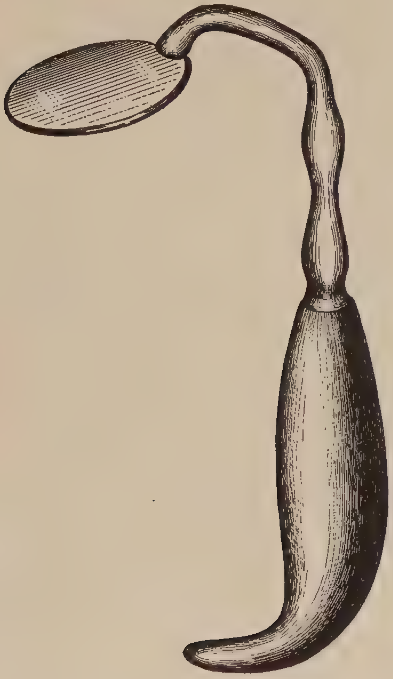


FIG. 15.—TUERCK'S TONGUE DEPRESSOR.

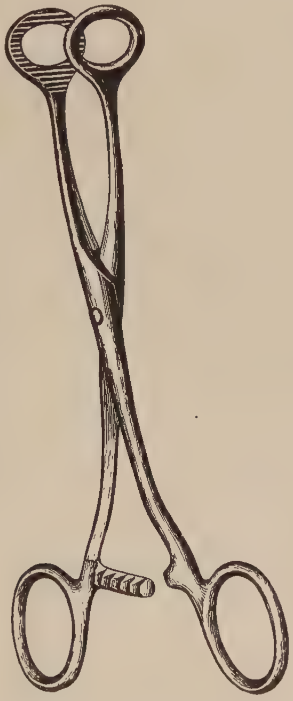


FIG. 16.—COLLINS' TONGUE FORCEPS.

Cheek Retractors.—Of the cheek retractors, Luer's is an excellent one. A plain blunt medium sized surgical retractor answers very well. (Fig. 14.)

Tongue Tractors.—As a tongue tractor, a loop of heavy silk passed through the anterior part of the tongue is the best. The after-disturbance in the tongue is less than that following the application for a similar length of time of any of the so-called tongue forceps.

Tongue Forceps.—Of the tongue forceps, the light weight Collins' is excellent. (Fig. 16.)

Small blunt silver probes or fine flexible whalebone guides for use in operation on the ducts.

Other Instruments.—Hypodermic syringes and needles; scalpels; smooth and mouse-toothed anatomical forceps; straight and curved scissors; blunt and pointed scissors with long handles; straight and curved artery forceps; small mosquito artery forceps; double tenacula; blunt and sharp skin retractors; curved blunt ligature carriers; small trocar and cannula; needles and needle holders; small rubber drainage tubing; apparatus for sucking saliva and mucus out of the mouth during the operation.

Instruments Where Bone Work Is Necessary.—Gigli saw; periosteal elevator; rongeur forceps; bone forceps; bone-cutting forceps; bone drills; bronze wire and wire-cutting forceps; bone curets; bone wax.[1]

METHOD OF ANESTHESIA

Intra-oral Operations.—The following methods of anesthesia are recommended:

a. For short operations inside the mouth, such as incising a localized abscess, incising the mucous membrane over a sublingual calculus in the floor of the mouth, removing a small portion of tumor from the tongue or microscopic examination, etc., local anesthesia with 4 to 10 per cent. novocain solution, either applied to the mucous membrane or injected into the mucous or submucous tissue.

b. For short operations where local anesthesia is not desirable, general anesthesia through the tubes attached to one of the mouth gags (Jansen's, Gwathmey-Ferguson).

c. For operations of longer duration inside the mouth, where the presence of 1 or more tubes in the mouth does not interfere with rapid and thorough work, intratracheal insufflation anesthesia.

d. Where all available room inside the mouth is indispensable to the operator, and where the danger of the patient's inspiring blood or mucus during the operation is slight or negligible, nasal anesthesia through the nasal tubes.

e. Where all available room inside the mouth is indispensable to the operator, but where the danger of the patient's inspiring blood and mucus is great, general anesthesia through a previously made tracheotomy wound. This is the preferable method in some carcinomata of the tongue and in some pharyngeal tumors.

Extra-oral Operations.—In the removal of submaxillary or parotid glands and in preliminary clearing out of the glands of the neck for carcinoma of the tongue, etc., nasal anesthesia is excellent. The tubes are out of the operator's way and so is the anesthetist.[2]

In suitable cases rectal anesthesia induced by a skilled anesthetist with a trained assistant will prove to be of distinct help to the operator.

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[1] All instruments should be sterilized, of course, before using.

[2] For the technic of intratracheal and intranasal anesthesia the reader is referred to the article on that subject, Vol. I, Chap. III.

PREPARATION FOR OPERATIONS

Posture of Patient.—For short operations, the "head-low" position is sometimes of advantage. The dangers of inhaling blood and mucus are thereby minimized. The congestion of the vessels, however, which occurs in this position, especially in full-blooded adults, interferes greatly with the accurate recognition of anatomical structures. For extensive dissections this posture is, therefore, not favored. For most of the operations on the inside of the mouth, the position of the patient with the head and chest slightly elevated is to be preferred as giving the operator the best angle of vision.

Prevention of Inhalation of Blood or Mucus During Intra-oral Operations.—The dangers attendant upon this occurrence have had much influence in the past on the methods adopted by various operators in their intra-oral operations. With well-trained assistants who appreciate the importance of keeping the laryngeal way clear of all blood and mucus, an operator may be justified in performing many of the intra-oral operations while the anesthetic is being given, either through the nasal tube or through the tubes incorporated in the mouth gags for this purpose. When the vascularity of the parts involved is very great, the intratracheal method of anesthesia is a safer one.

The apparatus for aspirating saliva and bloody mucus from the mouth while the operation is in progress (see Vol. I, Chap. VII) introduces an additional element of safety in intra-oral operations.

Oral Asepsis.—Before undertaking any operation on the mouth, or one which may involve the removal of an organ communicating with that cavity, it is essential that the mouth should be made as aseptic as possible. Perfect oral asepsis is at present unattainable. Much may be done, however, to limit the number of organisms present. Carious teeth harbor great numbers of bacteria. They are also present between the teeth, between the gums and the teeth, between the gums and the cheeks, on the surface of the tongue, in and about the tonsils, behind the soft palate, and in the various recesses of the pharyngeal mucous membrane.

First of all, the services of a dentist should be secured to clean out and fill, either temporarily or permanently, all areas of dental caries that can be so treated. Carious teeth that are beyond repair should be extracted. All sharp edges of teeth should be smoothed off. All tartar should be removed from about the teeth, especially at their bases. When this has been accomplished, attention must be directed repeatedly for several days before the operation to the mechanical removal of portions of food that may collect in the mouth and of the great number of organisms that are constantly growing in the localities above mentioned. The teeth should be brushed 3 times a day with a *soft* tooth brush, using a mild antiseptic mouth wash or dental paste. The upper surface of the tongue should be brushed or scraped. Silk floss should be passed between all teeth while the wash or saponified paste is still in the mouth, and finally the mouth should be well rinsed with a mild solution of hydrogen peroxid (say equal parts of hydrogen peroxid solution U. S. P. and lime water). If these procedures are followed after each meal, the number of growing bacterial colonies will be greatly diminished. The nostrils and pharynx may be sprayed 3 times a day with a mild antiseptic solution such as a saturated solution of boric acid. If the gums are the seat of Riggs' disease, this process should receive appropriate treatment and a satisfactory condition should be secured before the date of operation is set. The patient should not be in a dusty atmosphere at any time within 24 hours of the operation. Male patients should be clean shaven on the day of operation. A mustache is likely not only to be in the operator's way, but also to contribute to soiling the operative field. A few minutes before the operation the routine method previously advocated for cleansing the mouth should be carried out.[1]

Where an operation is contemplated that will involve the opening of large tracts of cellular tissue in connection with the mouth (as in carcinoma of the tongue with removal of submaxillary glands and in extensive neck dissection) as an additional precaution the number of bacteria taken into the mouth during the 24 hours previous to the operation may be lessened by restricting the food to such sterilized articles as boiled water for drinking purposes, toast, boiled eggs, boiled milk and coffee, freshly cooked fruit, etc.

Asepsis of Skin and Subcutaneous Tissues.—Before undertaking any of the various operations for external salivary fistulæ it is important that the skin and subcutaneous tissues around the fistulous opening shall be brought into as good condition as possible. This is especially the case where end-to-end suture of the divided duct is contemplated. The excoriation of the skin and the chronic thickening of the subcutaneous tissues due to the constant bathing of them by the salivary stream can best be removed by protecting them against the saliva through the application of a salve, which should be both waterproof and of such firmness that it will not perceptibly soften at the body temperature. An ointment which answers this purpose admirably is made up as follows:

Zinc oxid ointment (U. S. P.)	4 ounces
White wax	1 ounce

To be heated and thoroughly mixed.

This ointment should be heated before it is applied. The skin should be thoroughly dried all around the fistulous opening, and the ointment then immediately applied. The saliva will flow over this ointment without melting it. In the old chronic cases it will probably require from 10 days to 2 weeks of careful treatment with this salve before the skin and subcutaneous tissues have returned to an approximately normal condition.

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[1] While antiseptic substances are doubtless beneficial in the sterilization of the oral cavity, irritation of the buccal mucous membrane may easily be brought about by too strong a solution or by too vigorous brushing of the teeth. An adequate mechanical removal of the bacteria is of more importance than the antiseptic action of the substances used.

OPERATIONS ON THE SALIVARY GLANDS AND DUCTS

CONGENITAL ABSENCE OF ONE OR MORE SALIVARY GLANDS

Congenital absence of one or more of the salivary glands does not call for operative procedure.

ABNORMALLY PLACED SALIVARY GLANDS

An abnormally placed salivary gland may give rise to an unusual swelling. Its removal might be indicated on cosmetic grounds. The condition is one of extreme rarity.

The operations for abnormally placed orifices of salivary glands will be described under the operations for fistulæ of the salivary ducts.

RECENT INJURIES TO THE SALIVARY GLANDS

When an injury occurs to one of the salivary glands on its buccal surface, a resulting buccal fistula is of slight importance. Operative attention is seldom required at the time, unless there is a complicating hemorrhage. Pressure applied in the wound is usually sufficient for the milder forms of hemorrhage. Where a large vessel is cut across or nicked, and it is found impossible to pick it up in the wound, the ligation of that vessel might be called for at its point of entrance into the gland (as the external carotid artery where it enters the parotid. These ligations will be found under their appropriate headings (Ligation of Arteries in Continuity, Chapter XI, Vol. 1, page 399). When a wound is inflicted on a salivary gland on its cutaneous surface, the operative treatment should follow the usual lines of wound treatment elsewhere, except that primary union of the overlying skin is specially to be desired on account of the possibility of the formation of an external salivary fistula. Dead spaces should not be left in such a wound to collect saliva and predispose to fistula. After appropriate closure of the wound, the jaw should be immobilized during the healing process. Fluid food should be given through a tube.

RECENT INJURIES TO THE SALIVARY DUCTS

An injury inflicted to one of the salivary ducts on its oral side, resulting in the formation of a salivary fistula in the mouth, does not call for special operative interference, for the exact location in the mouth of the opening of any of the salivary ducts does not seem to be of importance.

An injury inflicted on one of the salivary ducts on its cutaneous surface, which results immediately in an external salivary fistula, may call for operative interference. The divided ends of the ducts should, if possible, be coapted and sutured with fine chromicized catgut, the stitches not penetrating the duct lumen, however, for fear of subsequent calculus formation. The jaw should be immobilized and the patient fed through a tube. If, in such a wound, the mucous membrane of the cheek also has been opened, as in a penetrating stab wound, the wound in the mucous membrane may be left partially open, while the skin is carefully sutured, so that in the event of the duct not uniting, the saliva may be discharged into the mouth through the mucous wound. Should an external fistula form, which does not close as the wound heals, an appropriate operation will have to be performed. This condition is found usually only in wounds of the parotid duct. The operative procedures indicated will be described under Fistulæ of the Salivary Ducts.

REMOVAL OF FOREIGN BODIES IN SALIVARY DUCTS

If protruding from the orifices of the ducts, foreign bodies, such as bristles, fish-bones, hard particles of food, etc., may be seized with forceps and withdrawn. When imbedded in the duct beyond its orifice, an attempt may be made to milk the object back along the duct. This procedure, however, is usually unsuccessful, and the duct has to be opened for the removal of the foreign body. The appropriate operations for incising the various ducts are described under Removal of Calculus of the Salivary Ducts.

ACUTE INFECTIONS OF THE SALIVARY GLANDS

1. **Sublingual Gland.**—Acute purulent infection of the sublingual gland alone is rarely met with. A few cases, however, have been described. The abscess should be incised through the mouth in the long axis of the gland, and the wound either left wide open or preferably lightly packed with gauze for from 24 to 36 hours. After this, hourly rinsing with a mild antiseptic solution, such as saturated boric acid solution, will promote prompt healing.

2. **Submaxillary Gland.**—Acute purulent infection of the submaxillary gland requires prompt incision on account of the tendency of the inflammatory process to rapidly affect the cellular tissues of the neck. If unrelieved, edema of the glottis may supervene, necessitating prompt tracheotomy. A very liberal incision should be made from the cutaneous surface well into the substance of the gland, parallel to and just below the ramus of the jaw, avoiding, if possible, the facial artery at the posterior edge of the gland. Should the facial artery be cut, it is a mistake to pack the wound tightly to stop the bleeding. The divided ends should be ligated. The deep fascia should be divided to the full extent of the incision, thus relieving pressure. The wound should be very lightly packed. Should the presence of a foreign body in the gland or in the duct be suspected, careful search should be made for it. (Fig. 17.)

3. **Parotid Gland.**—Acute secondary suppurative infections of the parotid

gland are not uncommon. The pus is usually deep in the salivary portion of the gland or in the lymphatic gland situated within the parotid. Incision is made over the most prominent part of the brawny area in the same line as that of the facial nerve fibers. The capsule of the gland is divided to the full extent of the wound in order to relieve the pressure. Incision should be made at an early date to prevent the spread of the inflammatory process to the deep internal part of the parotid, which reaches almost to the pharyngeal wall. If this deep portion of the parotid becomes infected, the process may extend rapidly to the cellular tissue of the neck, owing to the absence of any dense limiting membrane to the gland in this locality. (Fig. 18.)

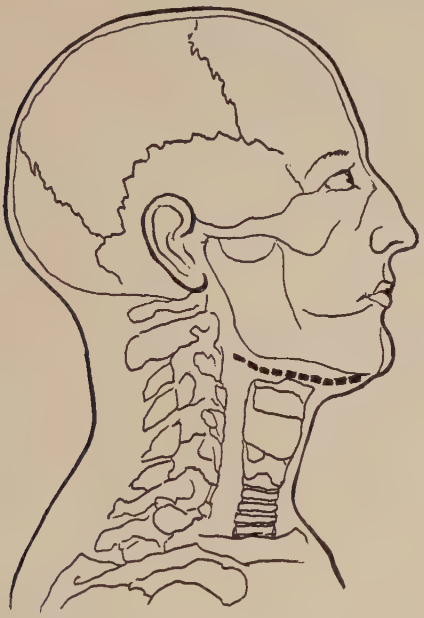


Fig. 17.—Incision for Abscess of Submaxillary Gland.

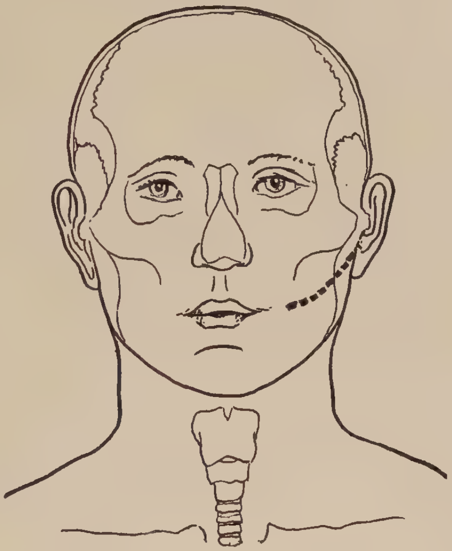


Fig. 18.—Incision for Parotid Abscess.

An abscess may rupture into the auditory canal or the pus may burrow down into the mediastinum or upward, causing thrombosis of the internal jugular vein and of the lateral sinus, with intracranial sepsis.

CHRONIC INFECTIONS OF THE SALIVARY GLANDS

The removal of the sublingual or submaxillary gland is at times indicated for a chronic inflammatory process (Kuetner's disease) which goes on to the production of connective tissue with minute abscesses scattered through the gland. The removal of these glands is described under Removal of Sublingual or Submaxillary Gland with Calculus.

The removal of the sublingual, submaxillary, or parotid glands may also be required for chronic enlargement interfering with function in the so-called Mikulicz' disease or syndrome.

REMOVAL OF CALCULUS OF THE SALIVARY GLANDS OR DUCTS

Removal of Calculus of Sublingual Gland or Sublingual Duct

1. **Removal of the Calculus Through the Mouth by Simple Incision of the Gland or Duct over the Calculus.**—This operation is suitable for a calculus in the sublingual duct, or in the sublingual gland where the calculus is not firmly imbedded in the gland tissue. (If firmly imbedded in the gland tissues, it is best to remove the gland itself with the calculus.) The lingual nerve, a branch of the inferior maxillary division of the fifth nerve, runs on the median side of the sublingual gland. The instruments to be used are: mouth gag, scalpel, artery clamps, scissors, blunt forceps, hypodermic syringe.

After novocainizing (4 per cent. solution) the portion of the gland directly over the calculus, a straight incision is made in the long axis of the gland over and down to the calculus, which is then seized with blunt forceps and extracted, whole if possible. Bleeding points are tied with plain catgut. The wound is left open. Injury to the lingual nerve should be avoided. It may be followed by loss of sensation of the anterior half of that side of the tongue. If the gland substance be left in a ragged condition, a re-formation of the calculus may occur.

2. **Removal of Calculus in the Sublingual Gland Through the Mouth, Together with the Sublingual Gland.**—When a sublingual calculus is firmly imbedded in the gland tissue, it is best to remove it with the gland. The sublingual gland rests on the mylohyoid muscle. To its median side are the lingual nerve and the duct of the submaxillary gland (Wharton's). Behind, the gland is in relation with the deep part of the submaxillary gland. General anesthesia is used through the nasal tubes. The instruments to be used are: mouth gag, scalpel, curved blunt scissors, artery clamps, double tenacula for holding up the gland, a square napkin of gauze for the assistant to grasp the tongue and hold it over to the opposite side, the salivary suction apparatus, if desired.

While the tongue is held over to the opposite side, the mucous membrane is divided in the long axis of the gland and peeled back by blunt dissection, exposing the gland, which is seized and held up by a double tenaculum. The assistant pushes up the floor of the mouth directly under the gland, and the gland with the contained calculus is enucleated from its bed with the curved scissors. Care is to be taken not to injure the lingual nerve on the median side of the gland and Wharton's duct. The mucous membrane of the mouth is left to fall into the hole made by the removal of the gland. Frequent use should be made postoperatively of a mild mouth wash. If the lingual nerve is injured, loss of sensation of the anterior half of the tongue on that side may result. If Wharton's duct is injured, there will probably be no permanent ill effect. If the dissection is a blunt one, the division behind between the sublingual and submaxillary gland would be recognized. If a portion of the submaxillary should be inadvertently removed with the sublingual, it is probable that no permanent bad effect will be noticed. Subsequent cellulitis of the floor of the mouth is best avoided by leaving the wound open. The loss of the sublingual gland seems to exert no appreciable influence on salivary digestion.

Removal of Calculus of Submaxillary Gland or Submaxillary Duct

Removal of Calculus of Submaxillary Wharton's Duct.—The superficial position of the submaxillary duct permits of the removal of a calculus imbedded in it through the mouth. The duct is about 2 in. long, and its walls are quite thin. The duct is crossed by the lingual nerve at the anterior border of the hyoglossus muscle, usually close to the anterior border of the submaxillary gland. The instruments used are: scalpel, artery clamps, scissors, mouse-toothed forceps, hypodermic syringe. Under local anesthesia (4 per cent. novocain), an incision directly over the calculus is made in the long axis of the duct, to prevent injury to the lingual nerve. The calculus is seized with the forceps and extracted. The wound is left open.

Removal of Calculus of Submaxillary Gland Through the Mouth.—This operation is not to be advised unless the stone is very superficial. This is unusual. The superficial calculi are usually located in Wharton's duct.

Removal of Submaxillary Gland with Contained Calculus Through the Mouth.—This operation is not considered safe on account of the depth of the gland, the dangers of wounding the facial artery below, and the lingual and hypoglossal nerves, whose location is apt to be obscured by capillary oozing.

Removal of Calculus of Submaxillary Gland Through the External Route.—The removal of the calculus alone, without the gland, through this route, while feasible, is not to be preferred unless there are local or general conditions to contra-indicate a more extensive operation. Where there is associated abscess or purulent infection of the cellular tissue in the submaxillary triangle, or where rapid removal of the calculus and thorough drainage of the submaxillary region are required, this operation is indicated. The position of the facial artery at the posterior part of the gland and of the lingual and hypoglossal nerves is to be kept in mind. The instruments required are: mouth gag, scalpel, artery forceps, sharp and blunt retractors, scissors, blunt forceps to seize calculus, sharp spoon. General anesthesia through nasal tube is indicated.

Incision is made over the most prominent part of the infected mass in the submaxillary triangle, and deepened until the gland is reached. With the mouth gag in position, the assistant depresses the submaxillary gland from the mouth, and the operator incises the gland directly over the calculus, which is then grasped by blunt forceps and delivered. Any necrotic gland tissue is curetted out by spoon. All the tissues are left open to drain, the operator having satisfied himself that the incision is sufficiently ample for adequate drainage.

The incision may be further extended into the cellular tissue of the neck if greater relief from tension be desired. Insufficient relief of tension may be followed by the spread of the cellulitis to the region of the glottis, necessitating tracheotomy later. An external salivary fistula may form. Re-formation of the calculus is not unlikely, unless the submaxillary gland is so necrotic that complete destruction of the gland tissue occurs.

Removal of Calculus of Submaxillary Gland, Together with the Gland, by External Route.—A calculus imbedded in the gland tissue, not associated with abscess or cellulitis in the submaxillary triangle, should be removed together with the gland. The position of the facial artery, at the posterior edge of the gland, and of the lingual and hypoglossal nerves, is to be kept in mind. The gland has a deep process which extends forward and inward above the mylohyoid muscle. The instruments to be used are: mouth gag, scalpel, retractors, tissue forceps, scissors, artery clamps, double tenacula, needle holders and needles. General anesthesia through nasal tubes is indicated.

An incision is made parallel to the lower border of the jaw and directly below it, corresponding to the length of the submaxillary gland. The tissues are divided down to the gland. The mouth gag is inserted and from the mouth the assistant pushes down the gland toward the operator. The gland, with contained calculus, is lifted up by a double tenaculum, and by blunt dissection the mass is gradually enucleated; its relation with the mylohyoid, styloglossus, and hyoglossus muscles, and with the facial artery posteriorly, being recognized. Wharton's duct is divided at its commencement and left in the wound. The mucous membrane of the floor of the mouth should not be broken into. A rubber tissue drain is left in the wound.

Removal of Calculus of the Parotid Gland or Parotid Duct

Removal of Calculus Imbedded in the Buccal Portion of the Parotid Duct.—The buccal portion of the parotid duct is from 1/2 to 3/4 in. long. It is the portion which extends from the edge of the masseter muscle, through the buccinator, to the opening on the buccal surface of the cheek opposite the second upper molar tooth.

The instruments required are: appropriate mouth gag, cheek retractor, scalpel, artery clamps, tissue forceps, hypodermic syringe, and needles. Local anesthesia (4 per cent. novocain solution) is employed.

Counter-pressure being made on the outside of the cheek, the anesthetic is injected into the buccal tissues directly over the calculus and the incision made in the long axis of the duct onto the calculus, which is then extracted. The wound is left wide open. If an internal salivary fistula forms at the site of incision, it is of no consequence. A mild antiseptic mouth wash should be used every 2 hours until healing is well under way.

Removal of Calculus Imbedded in the Masseteric Portion of the Parotid Duct.—The masseteric portion of the duct, which runs from the anterior edge of the parotid gland, lying on the masseter muscle, as far as its anterior edge, is about 1½ in. long. In its posterior portion it receives the duct of the accessory parotid gland. The course of the duct corresponds approximately to the middle third of a line drawn between the lower portion of the external auditory meatus and the middle of the upper lip. The duct wall is thick. Its diameter is about ⅛ in. It has branches of the facial nerve both below and above it. Above it is the transverse facial artery.

The instruments required are: scalpel, scissors, mosquito artery forceps, fine tissue forceps, small sharp retractors, fine curved needles, and needle holder. Local anesthesia (4 to 10 per cent. novocain solution) or general anesthesia through nasal tubes may be employed.

Incision is made in the line of the duct through the skin and superficial fascia and through the duct wall onto the calculus, which is then seized with forceps and withdrawn. The presence of any stricture in the proximal or distant part of the duct should be ascertained. If present, it should be dilated by the introduction of probes of increasing caliber. The edges of the divided duct should be accurately coapted with fine chromicized catgut sutures, which do not penetrate the lumen. The skin and superficial fascia should be brought together and sutured for primary union. The jaw should be immobilized for several days to promote primary union of the skin. Food should be given through a tube. Inaccurate coaptation of the divided edges of the duct or faulty union from necrotic edges may result in the formation of an external salivary fistula. Should this occur, sufficient time should be given for wound contraction in the hope that the fistula will gradually close, before resorting to a plastic operation.

Removal of Calculus Imbedded in the Glandular Portion of the Parotid Duct.—Calculi situated in the glandular part of the parotid duct are removed in the same way as those situated in the masseteric portion, except that the gland tissue is divided over the duct before the duct is incised. After the calculus is removed, the distal part of the duct should be probed for stricture. The edges of the incision in the duct are similarly sutured, and the gland tissue over it approximated by deep sutures to prevent the formation of dead spaces in which salivary puddles may form. The overlying skin is accurately sutured for primary union.

Removal of Calculus in Parotid Gland.—Here the removal of the calculus alone is indicated on account of the facial nerve filaments that perforate the parotid. General anesthesia is used through the nasal tubes. The instruments used are: scalpel, artery clamps, probe, scissors, small sharp retractors, tissue forceps, needles and needle holder.

The skin incision is made parallel to the course of the facial nerve fibers over the calculus. It is deepened through the gland until the calculus is exposed. The calculus is removed with forceps. If firmly imbedded, a little of the surrounding parotid tissue had best be removed by a clean scalpel dissection. Unless there has been some inflammatory involvement of the parotid, the wound may be closed without drainage, care being taken that no pockets are left for salivary puddles. Accurate skin apposition should be made in the hope of obtaining primary union and avoiding an external salivary fistula. The after-treatment should be as previously stated for a calculus in the glandular part of the duct.

REMOVAL OF CYSTS OF THE SALIVARY GLANDS OR DUCTS

Removal of Cysts of Sublingual Gland or Duct.—A cyst of the sublingual gland or of one of its ducts (one of the forms of the so-called "ranula") may be treated through the mouth in 1 of 3 ways: (a) By simple incision through the most prominent part of the cyst, after the local application of novocain solution to it. This will be curative in only a very small percentage of the cases. (b) By removal of the upper wall of the cyst by trimming away the loose epithelium after the incision of the cyst. This will give a somewhat greater percentage of cures than the first method. (c) By blunt dissection and removal of the cyst wall. In this method general anesthesia through nasal tubes is preferable. This procedure should be curative.

Removal of Cysts of Submaxillary Gland or Duct.—A submaxillary ranula that bulges into the mouth may be treated by removal of that part of the cyst wall which projects into the oral cavity, followed by the suturing of the raw edge to the mucous membrane directly around it, and by cauterization of the remaining base of the cyst, all under local anesthesia. Should the condition recur, the removal of the submaxillary gland through the external route should be carried out (see page 224). A cyst of the submaxillary gland which bulges externally should be enucleated by the external route. Freedom from recurrence, however, can only be assured by the removal of the gland together with the cyst as already described.

Removal of Cysts of Parotid Gland.—Cysts of the parotid are usually component parts of tumors of the parotid. Their operative removal is described under removal of the parotid. The removal of an ecchinococcus cyst should be carried out along the lines laid down for the Enucleation of Benign Tumors of the Parotid.

REMOVAL OF TUMORS OF THE SALIVARY GLANDS

Removal of Tumors of the Sublingual Gland

Primary tumors of the sublingual gland proper are rare. When the sublingual gland is affected by tumor growth, it is usually by secondary extension from a malignant tumor of the tongue or floor of the mouth and the removal is made with the original growth. For the removal of a benign tumor of the sublingual gland, see Removal of Sublingual Gland with Calculus.

Removal of Tumors of the Submaxillary Gland

The tumor is removed with the submaxillary gland (see Removal of Submaxillary Gland with Calculus).

Removal of Tumors of the Parotid Gland

1. Enucleation of Benign Tumors.—The instruments required are: scalpel, artery forceps, tissue forceps, sharp and blunt retractors, straight and curved scissors, probe, ligature carriers, needles and needle holder. General anesthesia is used.

When the tumor is of small or moderate size, incision is made over its most prominent part in the line of the facial nerve fibers. When the capsule is reached, it is separated from the surrounding glandular tissue by blunt dissection. Fairly free bleeding must be expected. Each bleeding point must be separately caught with mosquito clamps and later tied with fine plain catgut, oozing to be controlled by hot pad pressure. When the tumor is enucleated, it is important to spend some time in securing a dry field. The neighboring parotid tissue crowding into the hole left by the removal of the tumor will obliterate it to a marked degree. It is not advisable to put approximating sutures through the gland tissue or into its capsule. When hemostasis is satisfactory, the skin edges, together with the subcutaneous fatty tissue, are carefully approximated with fine black silk sutures and provision made in bandaging for moderately firm pressure over the wound, thus diminishing the probability of the formation of an intraglandular blood-clot and later of a salivary fistula. The skin sutures had best be left in, if possible, for 8 to 10 days, and light pressure with bandage kept up for another week. A subcuticular suture may be used, but it is important to bring the whole of the subcutaneous fatty layer in apposition over the wound in the gland. The escape of a few drops of saliva between the stitches in the first few dressings does not necessarily indicate the establishment of a salivary fistula.

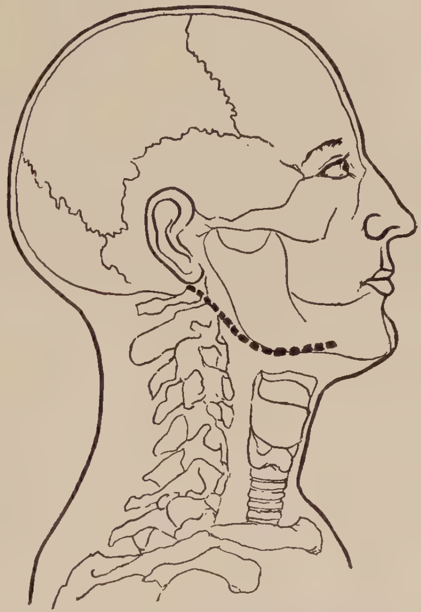


Fig. 19.—Incision for Large Benign Tumor of the Parotid.

For large benign tumors, owing to the fact that they often grow downward and outward, a curved flap incision is advantageously used, starting a little anterior to the lobule of the ear and following the posterior and inferior borders of the ascending and horizontal ramus of the jaw. On reflecting such a flap on to the cheek, the skin and subcutaneous fatty layers alone are dissected up, leaving the facial nerve fibers on the parotid or on the growth. The capsule of the tumor is then located and, by blunt dissection, the parotid gland tissue is pushed away from it, careful hemostasis being followed out as previously stated.

Judicious use may be made here of that valuable method of dissection in which, after getting the separation well under way in one place, and the capillary oozing in that part controlled by pad pressure, an adjoining part of the tumor is similarly attacked, return being made in a few minutes to the first area, where the field will be found comparatively dry and ready for deeper dissection. In this way the outlining dissection will proceed without waste of time, the smaller vessels being clamped and tied as seen. The deep part is thus left for the last, where, with an open wound and the tumor mass held to one side, the deep vessels can most clearly be recognized and dealt with. Where the facial nerve fibers can be recognized running directly over the capsule of the tumor, they can be lifted up with some surrounding cellular tissue to prevent the bruising of their nutrient vessels, or gently pushed out of the way upward and toward the base of the flap. If, after careful hemostasis, any dead spaces are found, they should be drained, preferably by small pieces of rubber tissue lightly smeared with sterile white vaselin. The skin flaps are to be sutured together with the subcutaneous tissue, avoiding the facial nerve fibers. (Fig. 19.)

The method in which the tumor is first split open and removed, without its capsule, is not to be recommended. The removal of the capsule, which has then to be undertaken, is apt to be associated with much freer bleeding, apparently from the venous engorgement that follows relief from pressure.

2. Complete Removal of the Parotid Gland for Malignant Tumors.—The parotid is somewhat saddle-shaped astride the posterior edge of the ascending ramus of the lower jaw, the external part being spread out over the masseter muscle, the internal, somewhat wedge-shaped, reaching almost to the mucous membrane of the pharynx. The superficial part is covered by the unyielding deep cervical fascia. The internal part has a very thin covering. Lymphatic glands are situated on the parotid as well as in the substance of the gland and along the external carotid artery during its course through the parotid. During the extracapsular removal of the parotid gland the following structures will be divided: The external carotid artery, branches of the posterior auricular artery to the parotid, the superficial temporal artery and its branch, the transverse facial, the temporal and internal maxillary veins, the posterior auricular vein, the external jugular vein, branches of the facial nerve and branches of the great auricular and auriculotemporal nerves. Following this operation, therefore, we would have paralysis of the buccinator, orbicularis oris, the muscles of the lower lip and chin, the orbicularis palpebrarum, the levator labii superioris et anguli oris, the levator labii superioris alæque nasi, the small muscles of the nose, the frontal part of the occipitofrontalis, and the corrugator supercilii muscle; also anesthesia of the skin over the parotid and to a certain degree of the skin over the temporal region. As a result of this, we have to tell the patient suffering from a malignant neoplasm of the parotid that the proper removal of the growth will be followed by paralysis of half of the face and by a certain amount of numbness of the skin as well.

The instruments to be used are: scalpel, artery forceps, scissors, retractors, aneurysm needle, tissue forceps, needle holder, needles, and probe.

Parotid tumors, even of moderate size, stretch out and distort the overlying skin to such a degree that, unless allowance for flap retraction be made in the placing of the skin incision, the operator may find at the completion of the operation that the flap edges come together in a different line from that desired. The proper incision for any given case will depend somewhat, therefore, on the relative size of the various portions of the tumor which is to be removed. In a general way the center of such an incision or the center of the flap, if a trap-door incision be used, should correspond closely to that part of the wound where the deepest dissection has to be carried out. If the tumor is one that has become adherent to the skin, the wide removal of such adherent portion together with the tumor is indicated. The least disfiguring of the various skin incisions, when it can conveniently be used, is the one starting from a point a little anterior to the auditory meatus and curving downward, parallel to and a little back of the posterior and inferior edges of the ascending and horizontal ramus of the jaw. Other incisions of marked adaptability are: (a) A Y-shaped incision beginning one inch in front of and a little above the external auditory meatus, and continuing downward to the angle of the jaw, prolonged then still further downward along the anterior edge of the sternomastoid for from 2 to 3 in.; the other end of the Y being an incision from a point just posterior to the mastoid process to meet the previous incision at the angle of the jaw. When the flaps of this incision are dissected back and retracted, excellent access is secured to the deep part of the parotid gland where the external carotid artery pierces it, and to its deep tongue-like process, which extends almost to the pharyngeal mucous membrane. It likewise affords good access to the deep cervical glands. (b) A T-shaped incision, the vertical part being in front of the ear, the horizontal part running forward a variable distance from the center of the vertical portion. (Figs. 20 and 21.)

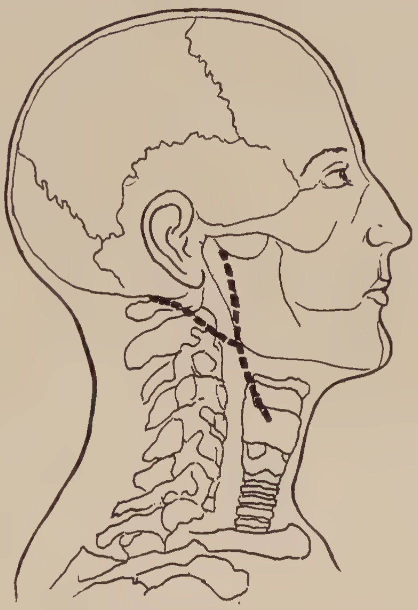


Fig. 20.—Y-shaped Incision for Removal of Parotid Tumor.

The skin and superficial fascia are reflected down to the parotid fascia. The anterior part of the gland and tumor is freed from the underlying masseter, all vessels being divided between clamps. Stenson's duct is severed anteriorly, and a clamp left on the tumor side of the duct to prevent the possible escape of broken-down tumor tissues through it into the wound. With the anterior part of the gland well lifted up, a clean dissection of the lower part is facilitated. This is continued below until the area of separation between the parotid and submaxillary glands is reached, the stylomandibular ligament separating the two at this point. Dry gauze is now introduced to check oozing, and return is made to the upper part of the wound where, after dividing the superficial temporal vessels, the parotid is freed under the lobule of the ear and back as far as the sternomastoid muscle. The parotid fascia, which, as one of the leaves of the deep cervical fascia, is continued over the sternomastoid, is dissected up from the anterior surface of the muscle a short distance, so that the muscle belly may be retracted backward. This will give a good exposure at the deep part of the parotid. Returning now to the lower part of the wound, the parotid is lifted well up and the external carotid artery is sought for. It is divided between ligatures at the point where it emerges from under the posterior belly of the digastric and the stylohyoid muscle. Elevating the gland still further, it is dissected up and freed from the stylomandibular ligament, the styloid process and the styloid group of muscles, and posteriorly from under the sternomastoid muscle and mastoid process of the temporal bone. The remaining portion of the gland is then carefully freed by blunt dissection from the internal carotid artery, internal jugular vein, and pneumogastric and glossopharyngeal nerves, and from the temporomaxillary joint above. Care should also be taken not to open into the pharynx during the removal of the deep part of the tumor. Should any secondarily enlarged cervical glands be palpable, they should, if the patient's condition then warrants it, be removed at the same time. The prolongation downward of the vertical arm of the Y skin incision above described will facilitate this part of the operation. A small rubber tissue and gauze cigarette drain should be placed in the deep part of the wound and brought out in the lower part of the incision.

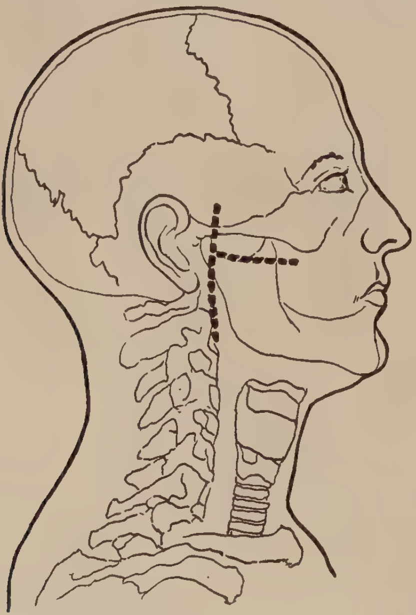


Fig. 21.—T-shaped Incision for Removal of Parotid Tumor.

Owing to the difficulties attendant upon the complete removal of the parotid gland, from the fact that the deep process of the gland is overlapped by the ascending ramus of the jaw, portions of the malignant tissue may easily escape detection. Zarraga proposes the following method of removal of the parotid together with the ascending ramus of the jaw in one piece:

Through a trap-door incision, the ascending ramus is separated from the horizontal with the Gigli saw. The ascending ramus is then rotated upward and outward, still adherent to the parotid, and the vascular connections of the gland ligated. The gland is then dissected free from all other attachments and removed together with all of the ascending ramus.

While this method offers distinct advantages in the cases where the bone is secondarily involved, the resulting functional disability should be carefully considered; also the likelihood of a rapid recurrence of any growth which has proceeded to such an extent that this operation would seem to be indicated.

In order to secure a better exposure of the deep part of the gland Faure recommends the removal of a portion of the posterior edge of the ascending ramus of the jaw, about 1 cm. wide, from the base of the condylar process to the angle of the jaw. The weakening of the jaw is slight.

FISTULÆ OF SALIVARY GLANDS OR DUCTS

Fistulæ of the Sublingual Gland or Duct

Fistulæ of the sublingual gland or duct which open into the mouth call for no operative treatment.

Fistulæ of the sublingual glands or ducts opening externally are rare. A removal of the sublingual gland through the mouth would be the operation of choice. (See Removal of Calculus of Sublingual Gland.)

Fistulæ of the Submaxillary Gland or Duct

A fistula of the submaxillary gland which opens into the mouth calls for no operative procedure. A fistula of the submaxillary gland or duct which opens externally had best be treated by the removal of the submaxillary gland by the external route. (See Removal of Calculus of the Submaxillary Gland.)

Fistulæ of the Parotid Duct

Operations for Fistulæ of the Buccal Portion of the Parotid Duct.—INTERNAL FISTULÆ OF THE BUCCAL PORTION OF THE PAROTID DUCT.—These fistulæ do not call for operative interference unless the mouth of the fistula becomes obstructed. In this case the division of the obstructing tissue is all that is indicated.

EXTERNAL FISTULÆ OF THE BUCCAL PORTION OF THE PAROTID DUCT (anterior to the masseter muscle) may be treated in one of several ways:

1. End-to-end Suture of the Duct after Excision of the Fistula.—This operation, while feasible in certain cases, presents no advantages over the less complicated ones to be next described. It also entails a cutaneous incision in the cheek, which some of the other methods avoid. It is not recommended. Should it be used, however, a good result will be more certain if the opening of

Stenson's duct in the mouth be mobilized backward by a crescentic incision through the mucous membrane of the cheek just anterior to the opening (Nicoladoni).

2. Von Langenbeck's Operation.—This operation converts an external into an internal fistula. By external incision, Stenson's duct with the fistula is dissected free from its masseteric bed, back from the fistula to the gland, and left attached to the gland. The free patulous end is then passed through a stab slit in the mucous membrane of the cheek into the mouth and there sutured. The stab opening is made in such a position that there will be no tension on the duct when sutured to the mucous membrane inside the mouth. (Fig. 22.)

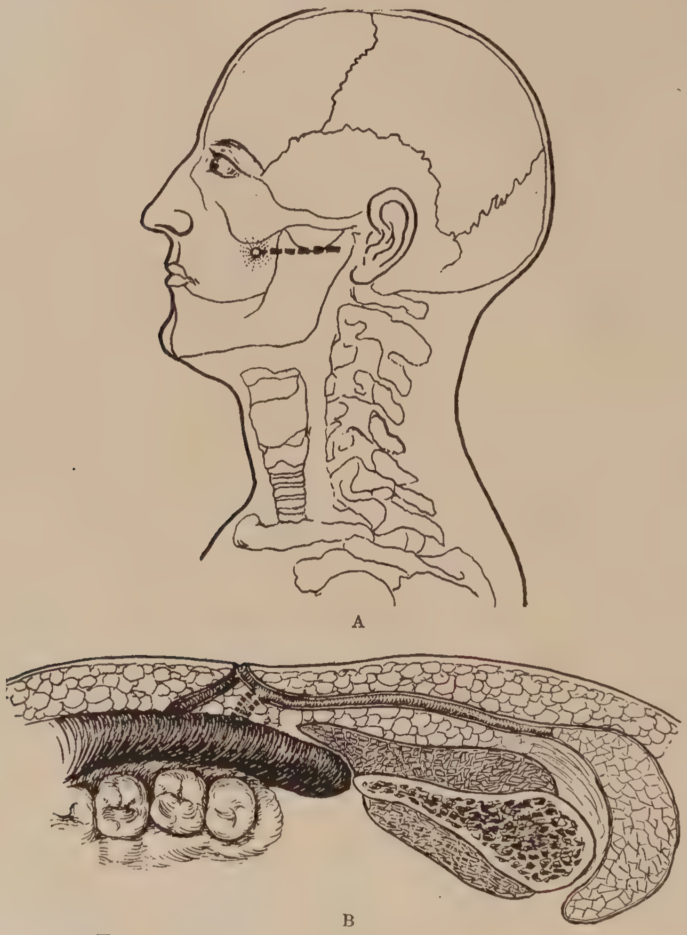


Fig. 22.—Steps in von Langenbeck's Operation.

3. De Guise-Pierce-Gould's Operation.—This operation also converts an external into an internal fistula. The internal fistula is obtained by causing a necrosis of the tissues of the cheek internal to the fistula through the pressure of a ligature. The most convenient method of performing this opera-

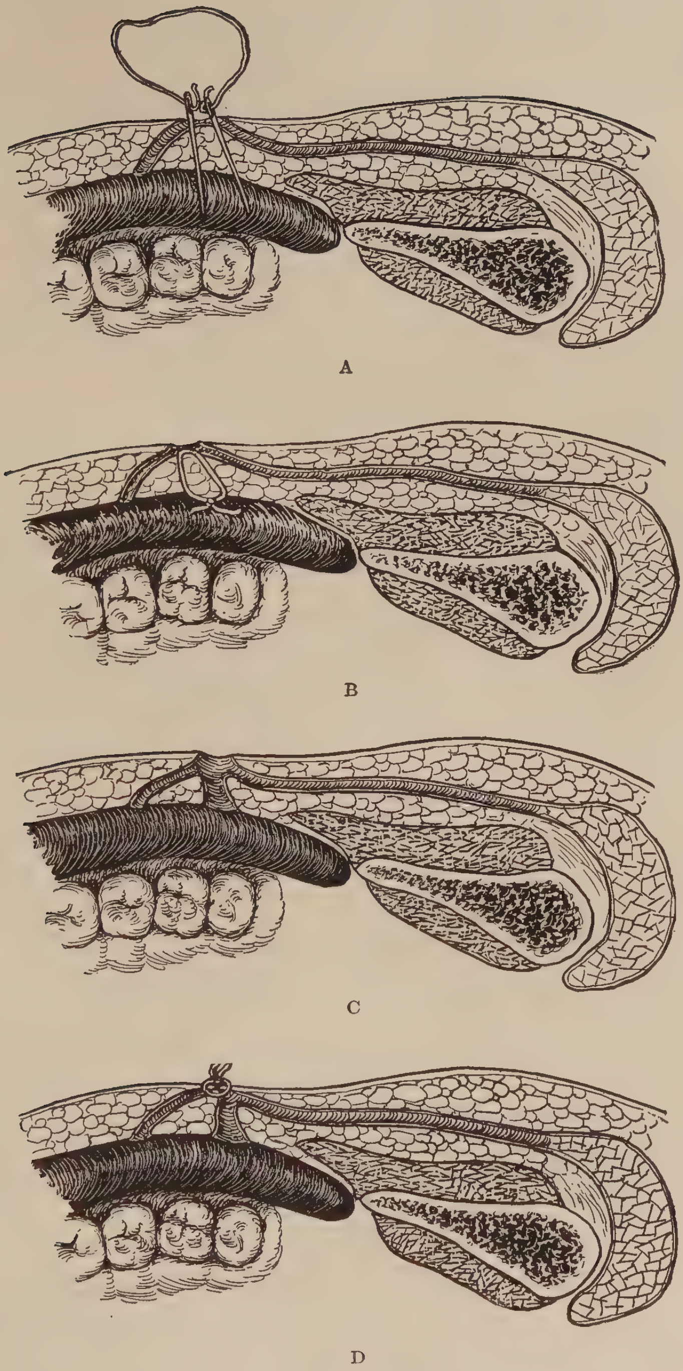


Fig. 23.—Steps in De Guise-Pierce-Gould's Operation.

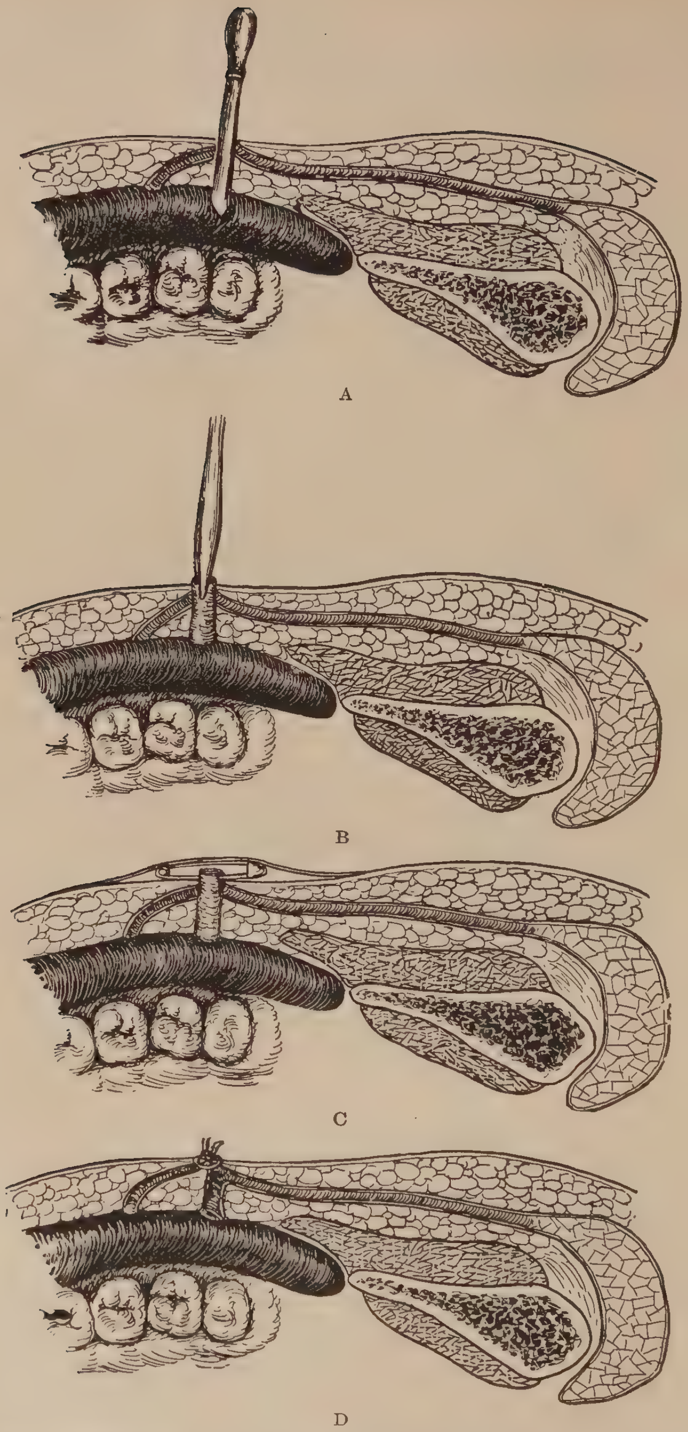


Fig. 24.—Kaufman's Operation. A, Opening made by trocar; B, insertion of rubber tube; C, retention of rubber tube; D, external opening suture.

tion is with the aid of heavy silk ligature, about 8 in. long, threaded with a straight needle at both ends. One needle is passed into the opening of the external fistula and through the cheek tissues in a slightly forward direction. Before passing this needle entirely through, the other one is passed similarly into the opening of the external fistula, but in a backward direction. This will include a somewhat wedge-shaped piece of tissue between the 2 needles. The needles are then pulled out through the mouth and the ligature tightly tied. After the included tissue has necrosed into the mouth, the opening of the external fistula on the cheek is freshened and the skin edges sutured. (Fig. 22.)

4. KAUFMAN'S OPERATION.—This operation, like the two preceding, converts an external into an internal fistula. In this method a small rubber tube, about 3 mm. in thickness, is passed into the mouth through an opening made by pushing a trocar through the tissues of the cheek from the external fistula. The rubber tube is retained until epithelialization of the tract is considered to be well under way (2 to 3 weeks), when it is withdrawn. The opening of the external fistula is then freshened, and its edge united by suture. (Instead of the rubber tubing, a heavy silk cord may be used.) The rubber tubing may be prevented from slipping in or out by fastening a small safety-pin in the outer opening, and placing sterile adhesive plaster over this to keep it attached to the skin of the cheek. (Fig. 24.)

Operations for Fistula of the Parotid Duct in the Masseteric Portion.—The length of the masseteric portion of the parotid is about 1¾ in., lying on the masseter muscle from the anterior edge of the gland to the point where the duct dips through the buccinator muscle.

1. END-TO-END SUTURE OF THE FRESHENED ENDS OF THE DUCT.—The cicatricial tissue about the fistula opening is carefully dissected away, the proximal and distal ends being recognized in the wound. They are united with fine chromicized catgut sutures which do not penetrate the lumen. The skin and superficial fascia are closely united over the duct suture, and the jaw immobilized. The patient is fed through a tube. In a favorable case where there is no obstruction to the terminal part of the duct, union may be expected, or if slight leakage only results, gradual closure will ensue. Should there be obstruction in the terminal part of the duct, the obstruction should be dilated with graduated probes before the duct ends are sutured.

2. SUTURE OF DIVIDED ENDS OF THE DUCT AFTER MOBILIZATION OF THE DISTAL PORTION OF THE DUCT (NICOLADONI).—After freshening the divided ends of the duct, as previously described, the distal part of the duct is dissected free through an external incision as far as the caruncle. A crescentic incision through the mucous membrane just anterior to the caruncle will permit of the displacement backward of the outlet of the duct for about 1.5 cm., thus relieving the tension on the end-to-end suture line. (Fig. 25.)

3. VON LANGENBECK'S METHOD.—If the fistula is not too close to the parotid gland, permitting the mobilization of sufficient length of parotid duct, the method of von Langenbeck, previously described, may be selected and the

duct passed through a generous opening made in the masseter muscle, either by separating its fibers or dividing them transversely. If the anterior edge of the ascending ramus is in the way, it may be guttered to the depth desired. The opening of the duct will then be located just in front of the anterior pillar of the fauces. (Fig. 25.)

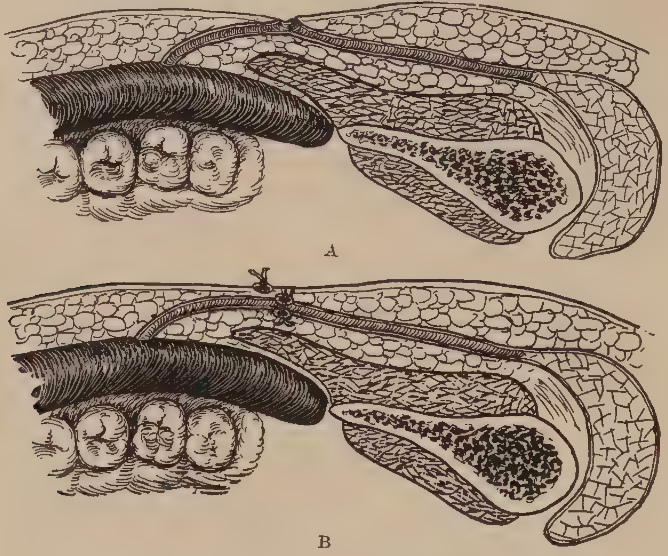


FIG. 25.—NICOLADONI'S OPERATION.

4. BRAUN'S OPERATION.—In this operation a new salivary duct is constructed lined with mucous membrane fashioned from the mucous membrane of the cheek, as follows:

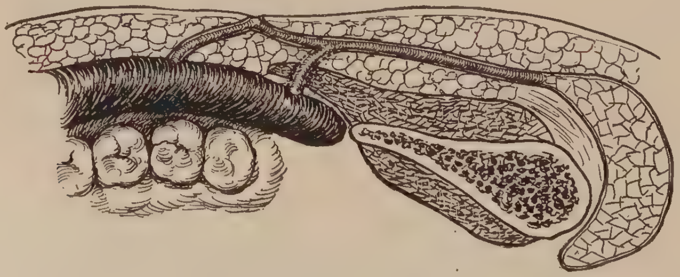


FIG. 26.—VON LANGENBECK'S OPERATION. Duct passed through masseter muscle.

The fistula is dissected free from the subcutaneous tissues and an incision made in the cheek, running forward parallel to the facial nerve fibers and about 2 in. long. After retracting the skin and subcutaneous tissues, the anterior edge of the masseter is sought for. The edge will be the base of a quadrilateral flap of mucous membrane, about 1½ in. long by ¾ in. wide, which is made by incising the mucous and submucous tissues into the mouth.

After detachment, the flap is turned back over the anterior edge of the masseter and converted into a tube by uniting the upper and lower edges with chromicized catgut, the mucous membrane being turned inside. The opening of the fistula, which has previously been dissected out, is invaginated into the free end of the new tube and there retained by chromicized catgut sutures, which do not

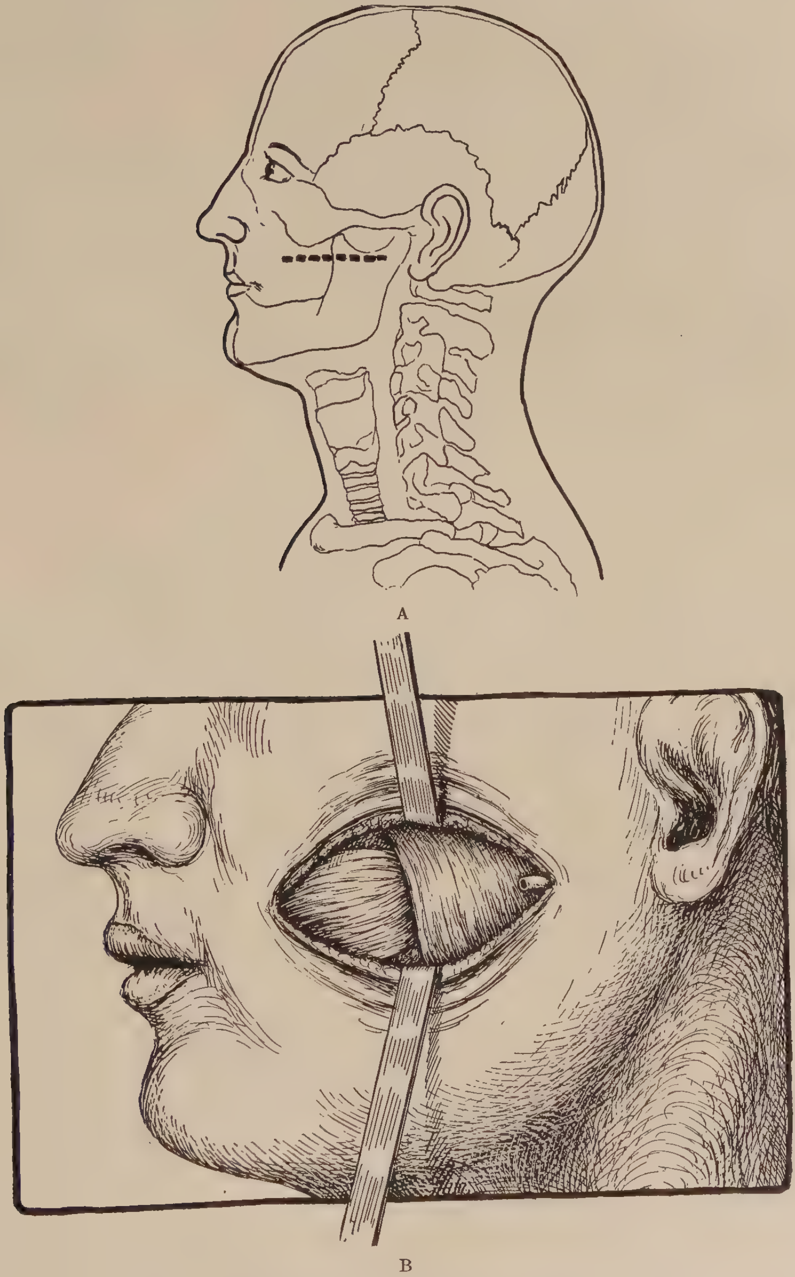


Fig. 27.—Incision and Various Steps in Braun's Operation.

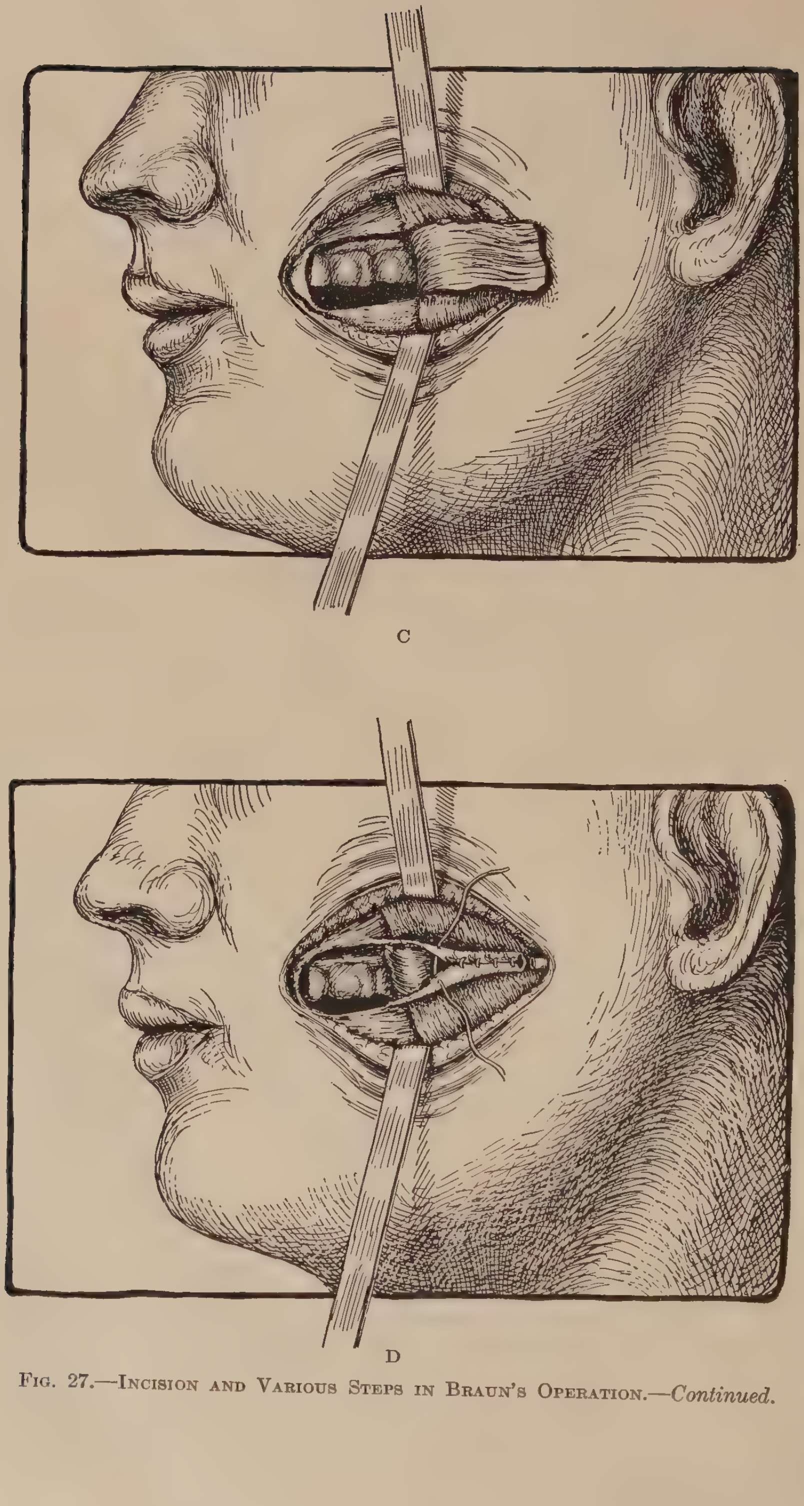


Fig. 27.—Incision and Various Steps in Braun's Operation.—*Continued.*

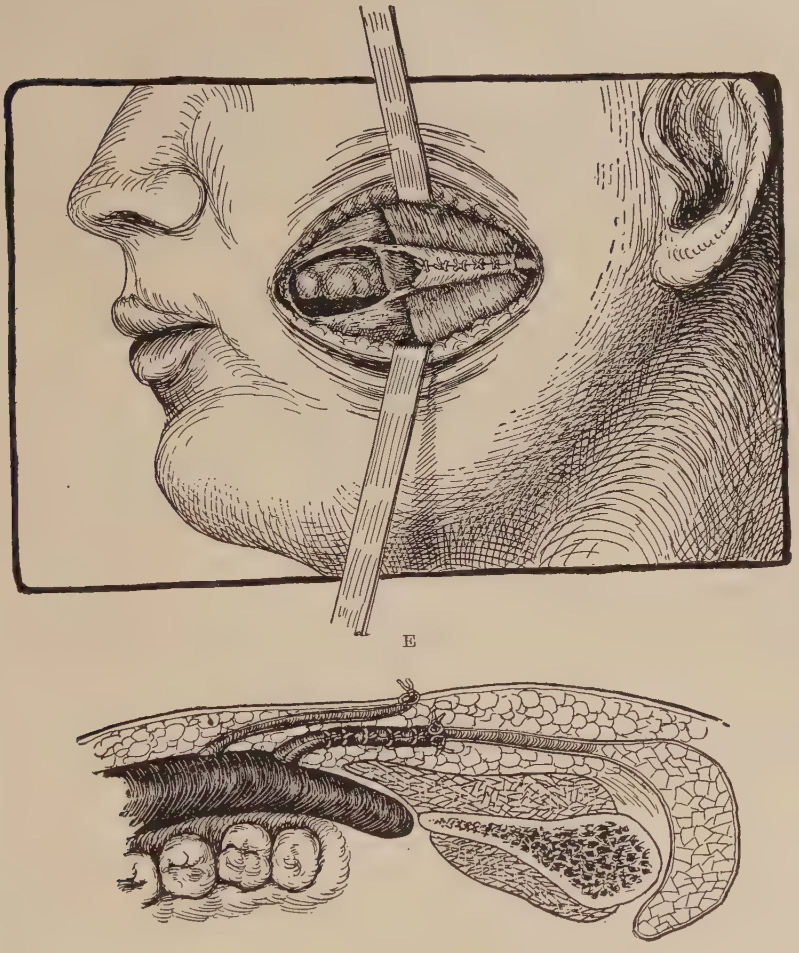


FIG. 27.—INCISION AND VARIOUS STEPS IN BRAUN'S OPERATION.—*Continued.*

penetrate its lumen. The skin edges are brought accurately together for primary union, and the mucous membrane wound in the mouth left to granulate. If it is found that the flap has been cut a little too short, the anterior edge of the masseter can be trimmed away to permit lengthening of the flap, and if necessary, a portion of the anterior edge of the ascending ramus can also be removed for the same purpose. (Fig. 27.)

5 and 6. KAUFMAN'S AND DE GUISE'S METHODS.—These methods, previously described, can be used for fistulæ in the masseteric part of the duct, the tract in this case being made to run obliquely under the subcutaneous tissue to the edge of the masseter muscle, then piercing the mucous membrane of the mouth. (Fig. 28.)

If it can be made out that the fistula is located in the duct of the *socia parotidis,* the removal of this accessory portion of the gland would be indicated.

Operations for Fistulæ of the Glandular Portion of the Parotid Duct. — If the fistula is one resulting from traumatism, end-to-end suture of the divided duct, according to the lines previously laid down, should first be tried. If a flow of saliva is seen issuing from the normal orifice of the duct in the mouth, as well as from the external fistula, it may be assumed that the external salivary fistula is either from the duct of the accessory parotid or from a branch of the main duct. In such a case the removal of the accessory parotid or of the portion of the gland that feeds the external fistula would be indicated.

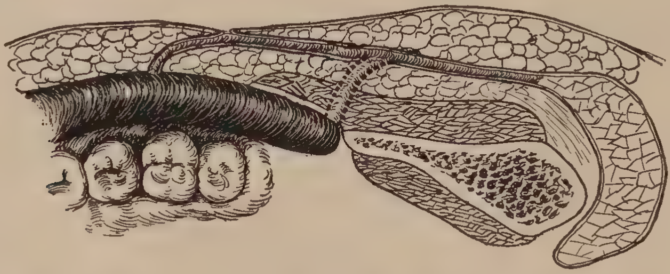


FIG. 28.—RESULT IN KAUFMAN'S AND DE GUISE'S OPERATION IN MASSETERIC PORTION OF THE DUCT.

ARREST OF THE SECRETION OF THE PAROTID.—When other methods have failed the arrest of secretion of the parotid has been attempted:

A. BY LIGATING THE PAROTID DUCT ON THE PROXIMAL SIDE OF THE FISTULA (BRENNAN'S OPERATION).—This is done in the hope that the ensuing fibrosis of the parotid will obliterate the secreting cells of the gland. Successes have been reported following this operation. The dangers, however, of abscess formation are such as to make this operation a hazardous one.

B. BY REMOVING THE PAROTID GLAND.—Should this operation seem indicated, it should be performed along lines previously laid down. Special care should be used to leave all the fibers of the facial nerve possible. (See Removal of Benign Tumors of the Parotid Gland.)

Operations for Fistula of the Parotid Gland.—Fistulæ of the parotid gland arising from traumatic causes usually heal without recourse to operation. Those arising from ulcerative processes (tubercle, abscesses, etc.) can only be cured by removal of that portion of the parotid which is involved, or by a complete removal of the gland. In such a case, careful attention must be paid to the facial nerve fibers that run on and through the gland.

OPERATIONS ON THE TONGUE AND FLOOR OF THE MOUTH

THE SUTURING OF INCISED WOUNDS OF THE TONGUE

In incised wounds of the tongue the accompanying hemorrhage is at times sharp. In wounds involving the anterior part of the tongue, unless one of the ranine arteries has been divided, digital pressure is usually sufficient to control the bleeding until sutures are introduced. As soon after the injury as is possible, in order to take advantage of the partial anesthesia present, the wound should be cleansed and the cut surfaces approximated with deep sutures of silk. In children it may be found necessary to insert a mouth gag and to resort to general anesthesia. Owing to the marked vascularity of the tongue, portions which have been almost severed from the main part may retain their vitality if the raw surfaces are promptly and carefully cleansed and accurately approximated. Stitches may often be removed on the fifth or sixth day on account of rapid healing. Fluid food only should be taken, and through a tube. Oral asepsis should be carried out as far as possible. The tongue should be kept quiet.

Where extensive laceration of the tongue has occurred, extending back into the posterior portion and associated with sharp hemorrhage, it is safer to resort to general anesthesia and to then expose thoroughly all raw surfaces, tying all bleeding points and searching for any foreign bodies. These are sometimes found deeply imbedded after they have penetrated the large vessels of the neck. Whitehead's mouth gag and the silk loop through the tip of the tongue will greatly facilitate the necessary procedures. Tracheotomy and the plugging of the pharynx to prevent inhalation of blood may be required at any time during the operation. Intratracheal anesthesia may be a distinct help in these cases if the necessary apparatus is at hand.

REMOVAL OF A FOREIGN BODY FROM THE TONGUE

When the presence of a foreign body in the anterior part of the tongue is suspected, as a piece of meat-bone, fish-bone, wood splinter, piece of sharp metal, etc., etc., and the diagnosis is confirmed by palpation or by X-ray, the mouth is cleansed in the manner previously outlined under oral asepsis and the tongue is held well forward with a piece of sterile gauze. A few drops of 4 per cent. novocain solution are injected hypodermically over the site of the greatest tenderness, and an incision made down to the foreign body with a scalpel. Digital compression on either side of the incision will control the bleeding, which is otherwise apt to be troublesome and to interfere with the prompt recognition of the foreign body. The body should be removed, if possible, in the reverse direction from that in which it entered the tongue. If the incision has been a large one, the wound surface should be sutured with silk, provision being made for drainage; if a small one, it may be allowed to heal without suturing. When the foreign body is in the posterior part of the tongue, general anesthesia (preferably intratracheal) may be necessary. A tracheotomy set should be at hand.

TONGUE-TIE

Congenital Tongue-tie.—When the frenum is so short that the tip of the tongue is held down in the floor of the mouth so that it cannot be protruded beyond the line of the lower gum, thus interfering with those movements of the tongue that are necessary for adequate nursing, the division of the short frenum is indicated. In dividing it, the location of the ranine arteries should be kept in mind. These vessels lie directly under the mucous membrane on the under surface of the tip of the tongue on either side of the frenum. The sublingual vessels lie in the floor of the mouth directly under the ranine. These vessels may be avoided as follows: After injecting a few drops of 1 per cent. novocain solution into the frenal area, the tip of the tongue is slightly elevated and the frenal band simply nicked with the scalpel. This is usually sufficient to bring up the tip of the tongue. If not, the wound may be enlarged posteriorly, directly in the midline by blunt dissection, with the handle of the scalpel. Should persistent bleeding occur, a fine catgut suture on a small curved needle should be passed directly under the wound and tied. The wound is left open. The mouth is washed 6 times a day with a saturated boric acid solution.

Operations for supposed congenital tongue tie are frequently performed without sufficient indication. If the baby can nurse, the operation should not be done until it is 6 months old. A history of hemophilia should always be sought for. A number of such fatal cases have been reported.

Acquired Tongue-tie.—When the tongue, through ulceration and subsequent cicatrization, has become adherent to the mucous membrane of the gums or cheeks, its separation from them is indicated. This may be done under local anesthesia, the incision following carefully the line of junction. To prevent reunion, sterile rubber tissue should be kept between the raw surfaces until the epithelial formation is completed. This is favored by keeping the mouth as aseptic as possible.

CONGENITAL FORKED TONGUE

A plastic operation may be indicated in this condition for cosmetic purposes. In such a case, after 4 per cent. novocain has been injected hypodermically into the field of operation, the mucous membrane of the median surfaces of the fork are removed with scalpel or scissors and the freshened planes brought together with deep silk sutures. These will be found to control the bleeding from the cut surfaces. The after-treatment is that mentioned under incised wounds of the tongue.

CELLULITIS OR ACUTE ABSCESS OF TONGUE

Where acute infection of the cellular tissue of the tongue occurs, producing rapid swelling of the organ, extension backward to the cervical planes should be prevented by free incisions into the substance of the tongue. These had best be made in the long axis of the organ, and on either side of the median raphe, as far back as the foramen cecum, if necessary. They should be of sufficient depth so that the submucous fibrous layer will be divided and the underlying tension relieved. Should the local lesion causing infection be apparent, it should either be removed or freely incised. If local anesthesia is not feasible, owing to the marked swelling of the tongue, general anesthesia through the nasal tubes should be resorted to. If a deep abscess is located, it should be opened by forcing a pair of blunt artery forceps into it, and kept open for a few days by a small piece of drainage gauze.

CHRONIC ABSCESS OF THE TONGUE

The mucous membrane over the most prominent part of the abscess is anesthetized with sterile 10 per cent. novocain solution, and the deeper tissues injected hypodermatically with a 4 per cent. solution. The incision is then carefully made through the mucous membrane and through the submucous fibrous layer, the end of a pair of blunt artery forceps being then forced into the abscess. The opening should be made of sufficient size so that a liberal gauze drain may be introduced. If it is desired to remove the abscess wall or to curet it, general anesthesia will be necessary.

MACROGLOSSIA

In macroglossia, when the tongue has reached such a size that both deglutition and breathing are interfered with, a reduction in the size of the organ is imperative. Rectal anesthesia in the hands of a special anesthetist offers many advantages. If not available, general anesthesia through the nasal tubes, or, if the case be an extreme one, anesthesia through a previously made tracheotomy opening is advisable. A silk loop is passed through the tip of the tongue in the midline, and the tongue is reduced to an approximately normal size by the excision of a wedge-shaped piece. By fashioning the wedge so that its apex does not quite reach the floor of the mouth, the lingual and ranine vessels and the lingual and glossopharyngeal nerves will be avoided. Bleeding vessels are tied with plain catgut. The raw surfaces are approximated with silk sutures.

If the removal of the longitudinal wedge does not sufficiently reduce the size of the tongue, a transverse wedge may also be removed at the same time, thus shortening up the tongue as well. This wedge had best be removed from the middle portion of the tongue or somewhat anterior to this point. It should not extend as deeply into the tongue as the longitudinal one.

The after-treatment is the same as that described under Incised Wounds of the Tongue.

CHRONIC GLOSSITIS

Butlin's Marginal Resection of the Tongue.—In cases of chronic irritation of the tongue where the margins of the enlarged organ show indentations from contact with the teeth, together with spots of superficial ulceration or leukoplakia, this operation is of distinct prophylactic value. The instruments required are: mouth gag, scalpel, scissors, artery forceps, mouse-toothed forceps, needle holder, and curved needles threaded with silk. A wedge-shaped piece of the tongue is removed all around its margins, including the dorsal papilla-bearing part only.

The technic is as follows: Under general anesthesia, preferably intratracheal, a silk traction ligature is passed through the tongue well back from its tip. The removal of the wedge is started at the tip by 2 incisions, each about 1½ in. long, parallel to the margin of the tongue, one directly under the margin of the tongue at its tip, where the smooth, shiny mucous membrane passes into the papillary layer; the other on the upper surface of the dorsum and at a sufficient distance from the margin to include all the thickened or ulcerated papillary edge. These 2 incisions are deepened so as to meet in the shape of a wedge, and when this wedge-shaped portion of the tip is drawn forward and downward, the operator is enabled to approximate the cut edges of the remaining part of the tongue. This approximation is done immediately in order to stop the hemorrhage, and the silk sutures introduced for this purpose are tied and left long for the subsequent convenient handling of the tongue. By extending the previous incisions, other similar wedge-shaped sections are taken on either side of the first and similarly sutured. In this way the margin of the tongue is gradually freed until a spot is reached corresponding to the last molar tooth. From this point, on either side, the wedge is made smaller and smaller, tapering off to mucous membrane only, so as to leave a flat scar. In fashioning this wedge, the incision under the margin of the tongue should follow closely the junction between the smooth lining of the mucous membrane of the under part of the tongue and the papillary layer of the edge and dorsum. The marginal, wedge-shaped portion, when removed, will be found to be of the shape of the letter U. There will be no vessels of marked size in this tissue. The tongue is kept as quiet as possible for 5 or 6 days, when the sutures can usually be removed. The oral cavity is washed with a mild antiseptic mouth wash every 2 hours. This operation diminishes considerably the size of the tongue, so that its new edge is removed from contact with the teeth.

REMOVAL OF CYSTS OF THE TONGUE

Mucous Cysts of the Tongue.—Retention cysts of the mucous glands of the tongue may be removed by blunt dissection after the injection of 4 per cent. novocain solution around them, or the projecting part of the cyst may be trimmed away in the manner described under Cysts of the Salivary Glands. The first method is preferable.

Hydatid Cysts of the Tongue or of the Floor of the Mouth.—When the diagnosis of such a cyst has been established, its complete removal is indicated. By injecting 4 per cent. novocain solution into the tissues around the sac a blunt dissection of it should be carried out. If the raw surfaces thus made are extensive, they should be approximated with silk sutures. If small, they may be allowed to heal by contraction.

Sublingual Dermoids.—A sublingual dermoid can best be removed through a transverse skin incision in the neck over the most prominent part of the swelling. The muscles are separated in the line of their fibers, at a right angle to the skin incision, until the capsule of the tumor is reached. Unless the cyst wall has been the seat of an inflammatory process, an extracapsular enucleation is easily carried out by blunt dissection. If there are bands connecting the cyst with the hyoid bone, these should be divided close to the hyoid. If hemostasis has been satisfactory and perfect asepsis has been maintained, the wound may be closed without drainage.

If the cyst wall has been the seat of a chronic inflammatory process fixing it in the surrounding tissues, its removal will require careful dissection through a wound of liberal size. In such a case it is better during the dissection to remove some of the adhering muscular tissue with the cyst wall rather than to leave any of the cyst behind. Traumatism to the lingual and hypoglossal nerves should be avoided if possible. A small rubber tissue and gauze cigarette drain should be left in the wound. Where the cyst wall is acutely inflamed simple incision of the cyst with the removal of its contents, followed by liberal drainage of its cellular bed, is indicated. The resulting sinus, together with the sac, may be excised at a later time.

REMOVAL OF ANGIOMA OF THE TONGUE

If small or of moderate size, the tumor may be removed after the injection of a sterile 4 per cent. novocain solution into the tissue around the tumor. The hemorrhage will not be troublesome if the incision is made everywhere into sound tissue, unless the ranine arteries be divided. Deep silk sutures will control the bleeding and approximate the wound edges. If preferred, the tip of the Paquelin cautery may be plunged into the growth in several places, reliance being placed on the subsequent obliteration of the vascular tissue by these means.

For large angiomata a preliminary ligation of 1 or both lingual arteries will be desirable.

Under general anesthesia, preferably intratracheal, Whitehead's mouth gag is introduced, and a silk loop is passed through the tongue. With this as a tractor, the tongue is drawn well forward, and the assistant compresses the tissues of the tongue just outside of the proposed incision. A rapid removal of the growth is made with the scissors, and through sutures of silk are immediately introduced and tied. This is usually sufficient to check the bleeding and to approximate the raw surfaces. If desired, additional fine silk sutures may be introduced to better approximate the surface epithelium. A mild mouth wash is used every 3 hours until healing is complete.

REMOVAL OF PAPILLOMA OF THE TONGUE

After anesthetising the papilloma and the surrounding tissue by the application of a 10 per cent. solution of novocain, the papilloma is seized with mouse-toothed forceps and held up. With a pair of scissors, curved on the flat, the growth, together with the epithelium at its base, is removed. Pressure with gauze for a few minutes is usually sufficient to check the bleeding. A mild mouth wash is used every few hours until cicatrization is complete.

REMOVAL OF LIPOMA IN THE FLOOR OF THE MOUTH

Such a tumor can best be removed through the incision described under Removal of a Sublingual Dermoid.

PRIMARY TUBERCULOSIS OF THE TONGUE

Where a diagnosis of primary tuberculous ulcer of the tongue has been made, the removal of the ulcer is indicated. A wedge-shaped incision should be made as described under Wedge-shaped Excision of a Very Early Malignant Growth (page 247), going wide of all affected tissue.

REMOVAL OF A SECTION OF A TONGUE TUMOR FOR MICROSCOPIC EXAMINATION

Where a tongue tumor is small, it is better to remove the whole tumor widely without cutting into it, rather than to run the risk of spreading some malignant elements. Should it prove to be malignant, the removal of the tongue and of its lymphatic drainage area would then follow. Should it be benign, the proper operative steps will have been taken. For a large tumor, where a reasonable doubt may exist, as in a supposed carcinoma supervening upon an old broken-down gumma or mucous patch, it is important to secure a piece of sufficient width and depth so that a number of sections can be studied. Such a piece should include a good-sized portion of both base and edge. The base of the ulcer should first be anesthetized with a local application of a 10 per cent. novocain solution, and a few minutes later a 4 per cent. novocain solution should be injected well below the base of the indurated portion to be removed. A V-shaped piece should be excised with a sharp scalpel, the greatest care being taken not to bruise in any way the area on either side of the portion removed. Pressure with gauze will usually control any bleeding that may occur. Sutures should never be introduced to narrow the wound. In a doubtful case it is better not to trust to the examination of a frozen section.

PRELIMINARY TRACHEOTOMY IN OPERATIONS FOR THE REMOVAL OF THE TONGUE

There has been, and still is, much difference of opinion as to the expediency of performing a preliminary tracheotomy in cases where the tongue has to be removed. It has been held that the postoperative pneumonias arose from blood and mucus gaining access to the lung during the operation. On the other hand, the contention has also been set up that the pneumonic process was one of later origin, from inability on the part of the patient, through loss of some of the muscles controlling deglutition, to properly direct the food. A clear field in which to work, without having to halt the operation every few seconds in order to remove blood and mucus from the pharynx, is certainly of great advantage to the operator. On this account many surgeons have preferred a preliminary tracheotomy.

The introduction of intratracheal anesthesia, however, is effecting a change in this respect, for during the anesthesia, neither blood nor mucus can gain access to the bronchial tubes.

If preliminary tracheotomy is performed, it is a safer procedure to wait for from 7 to 9 days, or until the temperature has reached normal, before undertaking the operation on the tongue or neck.

MALIGNANT DISEASE OF THE TONGUE

The operator has a choice of 3 routes in the removal of a malignant tumor of the tongue: (a) through the mouth; (b) through an opening made by dividing the inferior maxilla; (c) through the neck. He will be governed in his choice by the size of the tumor, its location, the involvement of neighboring tissues, and the presence of glandular swelling. For a very early case, where the growth seems confined to the epithelial covering of the tongue, and where there is no palpable or probable glandular involvement, a wedge-shaped excision through the mouth from ¾ to 1 in. away from the growth in all directions, under local anesthesia, is indicated. For a case that has penetrated the submucous tissue only, the removal of half of the tongue through the mouth, leaving in the tip if desired, supplemented later by a complete extirpation of the fat, lymphatic-bearing and salivary tissues of the submaxillary and anterior cervical triangles, is the method of choice.

Where the disease has progressed to deep induration with ulceration in the tongue, a removal of the whole tongue, together with the fat, lymphatic and salivary tissues in the submaxillary triangle through an opening made by dividing the lower jaw laterally, presents distinct advantages. Here, also, the removal of the tongue is to be supplemented by the clearing out of all remaining fat and lymphatic structures in the anterior triangle and under the sternocleidomastoid muscle. Where the tumor has progressed to involvement of the inferior maxilla, it is often questionable whether an apparently wide removal is justifiable, for both deglutition and respiration are necessarily interfered with by the extensive removal of the muscles involved. A better procedure would seem to be the starving of the growth by ligating the external carotid artery and the induction of analgesia by dividing or injecting one or both of the lingual nerves.

Wedge-shaped Excision of a Very Early Malignant Growth.—Where the growth is confined entirely to the superficial papillary layer of the tongue—before any thickening or submucosal involvement has occurred—this method is permissible. The tongue is held forward with a piece of sterile gauze. A 4 per cent. novocain solution is injected under the affected area (not into it) and a wedge-shaped piece of tongue is excised, going at least ¾ in. wide of the superficial edge of the lesion and 1 in. below its surface with the scissors or scalpel. Silk sutures are immediately introduced to control the bleeding and to approximate the cut edges. The mouth is kept clean with a mild mouth wash used every 2 hours. The sutures can usually be removed on the fifth or sixth day.

Removal of the Tongue or One-half of It Through the Mouth (Whitehead's Operation).—Where the tumor has not invaded the deep tissues of the tongue—that is, where the tongue and tumor are perfectly movable—the removal through the mouth by Whitehead's method is indicated. The position of the lingual arteries should be kept in mind, lying on either side, just under the mucous membrane at the base of the tongue.

The instruments required are: mouth gag, cheek retractor, scalpel, scissors, artery clamps, needle holder, needles, and 2 large needles threaded with heavy silk. A tracheotomy set should be at hand. Intratracheal anesthesia is made use of, if possible.

The patient is elevated to a sitting posture. Whitehead's gag, without the tongue depressor attachment, is inserted, and a silk loop is passed through the tongue at a safe distance from the growth. Elevating the tongue by means of this loop, the frenum is cut across with scissors. The mucous membrane is then divided on both sides, where it is reflected onto the inner surface of the lower jaw as far back as the anterior pillars of the fauces. The muscles at the base of the tongue are then sectioned, the lingual vessels being caught as seen. Before cutting away the posterior part of the tongue directly in front of the epiglottis, a silk suture had best be passed through the base of the tongue just anterior to the epiglottis and left long. By means of it traction may be exerted on the epiglottis by the nurse after the operation, should the patient become cyanotic or respiratory spasm supervene. Should hemorrhage occur from that part of the tongue, this loop will help bring the parts into view. If only half of the tongue is to be removed, the septum is split down the middle after the frenum and mucous membrane reflections on the affected side have been freed; the muscular attachments of the base of the tongue on that side are then cut across. The raw surface in the floor of the mouth may be painted, if desired, with styptic iodoform varnish. The patient should be carefully watched until he is out of the anesthetic to prevent the inhalation of blood or mucus. The mouth should be washed every hour or so with equal parts of solution hydrogen dioxid U. S. P. and sterile water. If deglutition is unsatisfactory, resort should be had within 24 hours to nutrient enemata. As soon as the patient can swallow comfortably and the postoperative nausea has ceased, the feeding should be pushed. In a few days, or as soon as the patient's condition warrants it, the submaxillary triangle should be cleared of all fat, lymphatic and salivary structures, and the glands along the carotid sheath removed. It is safer to do this secondarily, rather than at the time of the first operation, on account of the large amount of cellular tissue which would be exposed to absorption.

Statistics seem to show that the percentage of 4-year "non-recurrences" is greater after the Whitehead operation than after any of the others. This is reasonable, for the early cases are the ones best suited to this method. When the cervical glands have become involved in the malignancy it is probable that not more than 5 per cent. reach the 10 year limit. The most unfavorable cases are young patients with rapidly growing tumors and early glandular involvement. Almost all of these succumb within 2 or 3 years.

Billroth's Operation.—In Billroth's operation the tongue is removed through an incision under the chin following the lower border of the jaw on either side. The exposure is fair, but if the tumor occupies the side of the tongue, there is likelihood of its repeated contact with the raw surfaces of the wound during the operation. The muscles of the floor of the mouth are damaged, thus interfering somewhat with deglutition.

Removal of the Tongue Through the Jaw.—MODIFICATION OF THE V. LANGENBECK-SEDILLOT METHOD.—This operation is specially suited to cases of carcinoma of the tongue where the process has extended to the deep part of the tongue but where the floor of the mouth and the lower jaw are not involved. The operation about to be described combines the good features of the v. Langenbeck and the Sedillot methods. An important feature of the operation is the wide exposure that it gives of the affected side of the tongue, so that a clean handling of both tongue and tumor can be carried out, thus obviating operative contact between the tumor and the raw surfaces of the incision.

The relations of the lingual arteries and of the hypoglossal nerves (the motor nerves of the tongue) should be kept in mind.

The instruments to be used are: mouth gag, cheek retractor, blunt and sharp retractors, artery clamps, scissors, tissue forceps, drill, bronze wire, Gigli saw, wire twister and cutter, bone forceps, scalpel, needles and needle holder, 2 needles threaded with heavy silk. A tracheotomy set should be at hand. Intratracheal anesthesia may be used to advantage.

A preliminary ligation of the lingual artery of the opposite side is first performed (the lingual artery on the affected side is tied later, during the clearing of the submaxillary triangle).

A skin incision is made through the middle of the lower lip to the chin, curving then over to the affected side to about the middle of the anterior border of the sternocleidomastoid muscle. The flap is turned back by dissecting the soft parts from the lower jaw almost to the angle and raising the skin and subcutaneous tissues of the neck flap.

The submaxillary triangle is first cleared of all fatty, lymphatic, and salivary structures, working from below upward and leaving all hanging together. The lingual artery on that side is ligated.

With a bone drill holes are now bored on either side of the contemplated line of section, without reflecting the periosteum. The bone is divided a little anterior to the junction of body and ramus with a Gigli saw; the line of division being preferably S-shaped, bony surfaces fashioned in this way showing a greater tendency to remain in contact during the healing of the wound. The divided portions of the jaw are held apart with retractors and all raw surfaces are protected with gauze. The tongue is pulled upward by the silk tractor, its frenum incised, and the mucous membrane reflection from the tongue to the lower jaw divided all around. This brings the tongue well out. The deep muscles of the tongue are now cut across on the floor of the mouth, leaving the geniohyoid and geniohyoglossal fibers, if possible. All vessels are clamped as seen. The tongue being pulled still farther out of the wound, its connection with the anterior pillars of the fauces is severed. This leaves the posterior attachment only to the epiglottic region. A stout silk suture is now passed through the base of the tongue just anterior to the epiglottis, and the tongue divided close to this suture. All oozing points are carefully ligated with plain catgut and the raw surfaces washed with a solution of hydrogen dioxid U. S. P. The lower jaw is wired and the wound edges are approximated with silkworm-gut sutures. A gauze drain is placed in the floor of the mouth and brought out through the lower part of the lateral incision so as to drain the mouth and submaxillary fossa. The same general postoperative treatment is followed as that described under the Whitehead operation. As soon as the patient's condition will allow of it, a block dissection of the lymphatics in the neck is carried out, the fat and lymphatic tissue, together with the sternocleidomastoid muscle and internal jugular vein, being removed all in one piece (Crile). The deep parotid glands should also be removed with the tip of the parotid. To facilitate this work, a Crile clamp is temporarily applied to the common carotid artery in the lower part of the neck incision. The removal of the muscle does not seem to weaken the neck to any marked extent.

Butlin's method of clearing out the lymphatic tissue of the neck is less extensive than Crile's in that the sternocleidomastoid muscle is left behind.

LABADIE'S METHOD.—When the growth has invaded the floor of the mouth and the inferior maxilla, various operations are made use of, planned according to the location and extent of the involvement. When the growth has spread from the under surface of the anterior part of the tongue to the floor of the mouth and to the inferior maxilla, the method suggested by Labadie may be entertained.

In this operation the skin incision extends directly under the lower border of the jaw between the masseters. The soft parts are dissected up above from the bone, the mucous membrane of the lower lip being divided at its reflection on to the gums. A horizontal section is made with a Hay's saw through the lower jaw bone about its middle (or lower down according to the extent of involvement) and the upper portion removed by either sawing through the bone at right angles to the horizontal incision at either end or by chiseling through it.

The tongue is removed from $3/4$ to 1 in. wide of the growth. The expediency of such a palliative operation is, of course, open to doubt.

Anesthesia in Advanced Cases.—In the advanced cases suffering from cachexia, where the removal of the growth seems to be indicated in order to relieve the patient from the constant pain and foul discharge, but where the administration of a general anesthetic seems contra-indicated, the operative field may be anesthetized by novocainizing the lingual and inferior dental nerves at their point of junction. This is done through the mouth. The needle is inserted on a level with the lower jaw just behind the last molar tooth and pushed in slowly to the depth of about 3 cm., while the solution is being injected ahead of it. When the anesthesia is satisfactory, the needle is withdrawn. In addition to the above, it is well to block the larger vessels as they are encountered, and if the dissection is made as far back as the base of the tongue, the muscular tissue there should also be injected before it is sectioned.

OPERATIONS ON THE PHARYNX

REMOVAL OF A PEDUNCULATED TUMOR OF THE PHARYNX

After anesthetising the pedicle and the tissue at the base of the tumor by the injection of a few drops of a 4 per cent. solution of novocain, with the mouth kept open by means of a Whitehead gag, a silk ligature is slipped over the tumor and tied at its base, care being taken to include the basal tissue. The base is then cut away with a pair of long scissors.

REMOVAL OF A PHARYNGEAL TUMOR WITH A BROAD BASE

If the mucous membrane of the pharynx is freely movable over the tumor, the mass may usually be enucleated with ease through an incision directly over the most prominent part of the mass. Where this is not the case, the removal of the tumor may be effected through 1 of several routes, according to its location.

When the location is on the lateral pharyngeal wall near the pillar of the fauces, the method of von Langenbeck (previously described under Operations on the Tongue) may be adopted.

In von Mikulicz' method the skin incision is made along the anterior border of the sternocleidomastoid muscle from the mastoid to the hyoid bone, and the anterior flap reflected well up. A portion of the ascending ramus is resected without opening into the mouth, and the tumor is then removed from without, the mouth being opened only at the last, in order to remove the pharyngeal mucous membrane at a safe distance from the growth. Ample gauze drainage is left in the wound.

Where the tumor is situated posteriorly and low down, a lateral pharyngotomy offers the best exposure.

An incision is made from the mastoid along the anterior border of the sternocleidomastoid muscle to a point just beyond the level of the cricoid cartilage. The wound is deepened by blunt dissection, the large vessels being held out of the way by blunt retractors. A metal sound is introduced into the pharynx and cut down upon below the level of the tumor. The edges of the pharyngeal mucous membrane are seized with forceps, and the pharyngeal opening enlarged to the desired extent above. The tumor is dissected out together with the affected glands and all mucous membrane that may be found to be involved. If a small portion only of mucous membrane has been removed, the mucous edges are best sutured with chromicized catgut. If the removal of a large portion has been necessary, it is better to introduce a stomach tube through the wound for subsequent feedings. The wound should be amply drained, for even with generous drainage there will be a foul discharge which will last until granulation is well under way.

An occasional cure of a malignant tumor of the pharynx is reported. Owing to the fact that the pathology of a number of these pharyngeal tumors is not settled, reliable statistics are not obtainable.

RETROPHARYNGEAL ABSCESS

Where the abscess when first seen is about to perforate the mucous membrane posteriorly, the local application of a 10 per cent. solution of novocain may be made to it and the blades of a pair of long, blunt-pointed scissors pushed into the mass **while the patient is inverted** so that the pus will not be inhaled. The subsequent secondary infection, however, of such an open tract, which may lead to a bone focus above, is apt to prove troublesome. For this reason the opening of the abscess through the neck, when feasible, offers distinct advantages in the line of asepsis. The abscess may be opened through much the same incision as that previously described (lateral pharyngotomy), except that the pharynx is not opened, the abscess being entered behind the posterior pharyngeal mucous membrane. A rubber drainage tube should be left in (fitting loosely in the abscess cavity), and it should not be removed for a week or 10 days. Should it be withdrawn or should it fall out before then, its proper reintroduction may necessitate the giving of a general anesthetic.

REMOVAL OF A PHARYNGEAL DIVERTICULUM

For the removal of a pharyngeal diverticulum, see Diverticula of the Esophagus, Vol. III, Chap. X.

CHAPTER VI

THE OPERATIVE TREATMENT OF TONSILS AND ADENOIDS

Charles E. Farr

GENERAL CONSIDERATIONS

It may be confidently stated that no operation in the whole realm of surgery is so frequently attempted as the removal of tonsils and adenoids. As a corollary to this statement it may be truthfully said that no operation has to its credit so many partial or complete failures to cure or relieve the condition for which it was done. This is not to be wondered at when one considers that the operation is undertaken by innumerable physicians with little or no surgical training, slight knowledge of the regional anatomy, and nearly complete ignorance of the manipulations necessary to efficient work in the restricted operative field. The operation is really one of considerable difficulty and for thorough work requires far more skill than is generally appreciated.

Not only is the operation freely undertaken by utterly untrained men, but even the indications for operation are of the vaguest. At the present time there is a genuine operative furor on the tonsil and adenoid question. That every visible tonsil must be removed and that every child which opens its mouth occasionally must have its adenoids curetted, is the popular cry. Every parent knows the adenoid countenance and regularly inspects the throat of his child to find the much dreaded swelling of the tonsils. Unquestionably this wave of operative enthusiasm has gone too far and many operations have been needlessly done. There is bound to be a reaction and a return, it is to be hoped, to a saner view of the situation.

The lymphoid tissue of Waldeyer's ring, consisting of the pharyngeal and lingual tonsils and the nasopharyngeal adenoids, differs in no essential respect from lymphoid tissue elsewhere in the body except in its exposed situation and its peculiar anatomical arrangement. Like other lymphoid structures, and in much greater degree, it is especially subject to recurring inflammatory attacks of acute or chronic type and to hyperplasia from chronic irritation. This is very prone to occur in the young, just as do lymph-node infections and hyperplasias, enlargements of the spleen and the ends of the long bones, etc. So far as can be determined, this particular group of lymphoid structures has no function differentiating it from other similar structures in the body and its more or less complete removal works no harm *per se* to the human economy. The many thousands of cases in which this has been done with only beneficent late results is overwhelming proof of the harmlessness of the procedure. It only remains, then, to determine the rational indications for the operation.

TONSILLECTOMY

Indications.—The indications for the removal of tonsils are:

(1) Repeated attacks of acute tonsillitis.

(2) Marked enlargement of the tonsils.

(3) Chronic infection, as evidenced by plugging of the crypts, congestion of the fauces, ragged appearance of the tonsil, etc.

(4) Recurrent peritonsillar abscess.

(5) In persistent diphtheria carriers and those subject to recurrent attacks of diphtheria.

(6) Suspected cases of tuberculosis.

(7) Tumors.

(8) Tuberculous or other chronic enlargement of the subparotid lymph-nodes, without other obvious cause.

(9) Toxemias and infections originating in the tonsils but evidenced elsewhere. This is a large and rapidly increasing group, including rheumatism, chorea and endocarditis, cryptogenic arthritis and nephritis, malnutrition in children, and many other diseases. The diagnosis in this class of cases has to be made largely by exclusion, but the results in properly selected cases are exceedingly good.

Contra-indications.—These are the same as for any minor surgical procedure. Hemorrhage and shock are not inconsiderable in this operation and these, together with the physical condition of the patient, should be carefully weighed before even this apparently trivial operation is undertaken. Hemophilia, which cannot be controlled by serum injections, is an absolute contraindication to the operation, as is postdiphtheritic cardiac weakness. It is unwise, also, to operate in the presence of an acute infection of the ear, nose, or throat, unless an acute peritonsillar abscess demands it. The operation should not be done at the same time with other operative procedures, except, of course, the removal of adenoids, or possibly some trivial affair such as a circumcision. Finally, it is as well to emphasize that the burden of proof lies with the indications, not the contra-indications, and that the mere ability of the operator is not one of them.

Anatomical Points.—The faucial tonsils are collections of lymphoid tissue partially surrounded by a sheath of connective tissue, the "surgical capsule," which is deficient on the oral surface and occasionally at the base or lingual aspect. The oral surface, which varies greatly in size according to the depth the tonsil is buried, is covered by mucous membrane only. At its anterior and upper margin there occurs a fold or reduplication of this membrane as it passes over to the anterior surface of the anterior pillar of the fauces and in this fold is contained a prolongation of the fibrous capsule of the tonsil. This fold is known as the plica triangularis and is the most important landmark in locating the anterior margin of the tonsil. Behind and below it lie the great anterior and superior lacunæ of the tonsil, respectively, while in front of and external to it is the sharp internal margin of the palatoglossus muscle, covered by mucous membrane. The fibers of the palatoglossus run vertically from the soft palate to the base of the tongue, with the muscle of which they unite. All structures behind this muscle belong to the tonsil and must be removed in performing a complete enucleation of it.

External to the capsule of the tonsil lies the superior constrictor of the pharynx, the fibers of which run horizontally, separating the tonsil from the great vessels and nerves of the neck. Posteriorly lies the palatopharyngeus, which, with its covering of mucous membrane, forms the posterior pillar of the fauces. The fibers of this muscle run vertically, spreading out below on the lateral and posterior walls of the pharynx and uniting above with the palatoglossus to form the soft palate. The base of the tonsil is occasionally continuous with the lymphoid tissues of the base of the tongue known as the lingual tonsil, being separated from it only by one of the fibrous septa which abound in the tonsil proper.

It is thus seen that the tonsil is practically completely separated from the important structures of the pharynx by a fibrous sheath. This sheath, although firmly attached to the tonsil, is usually easily freed from the surrounding tissues in its entirety, and it is this fact that renders the enucleation of the tonsil a comparatively simple procedure.

The arterial supply of the tonsil consists of branches from the dorsalis linguæ of the lingual, the ascending palatine and tonsillar from the facial, the ascending pharyngeal from the external carotid, the descending palatine from the internal maxillary, and a small branch from the small meningeal. The veins unite to form the tonsillar plexus, which lies on the outer surface of the capsule, in and on the surrounding muscles. The most important are those uniting with the lingual vein and the pharyngeal plexus below, and a large vein running on the anterior surface of the palatopharyngeus behind. The nerves of the tonsil are derived from Meckel's ganglion and from the glossopharyngeal, while those of the surrounding muscles are from the internal branch of the spinal accessory through the pharyngeal plexus (Gray).

Anatomical anomalies in the tonsillar region are not common. Rarely the internal carotid is in close relation to the outer surface of the tonsil, and occasionally a rather large artery is seen passing over its oral surface. Pathological changes are, however, quite common, due to syphilis or other destructive lesions, or two growths or disease of adjacent structures. I have seen an aneurysm of the internal carotid from which a tonsil had been most skillfully dissected. Such instances, although rare, should lead to great care in studying the throat, especially in adults. Not every swelling in the tonsillar region is an enlarged tonsil. New growths are not rare and any attempt to enucleate them by methods suitable to ordinary tonsil work would be little short of disastrous.

Instruments.—Tonsillectomy is performed in a great variety of ways by different operators, and innumerable instruments and modifications of instruments have been devised for the operation. The method which I prefer is Mathews' finger enucleation, which is unsurpassed for simplicity, safety, and celerity of performance. For it very few instruments are needed—in fact, none are essential. To facilitate the work, however, the following instruments have been found helpful: (1) a pair of Dowd's curved dissecting scissors, (2) Beckman's adenoid curet, (3) long-toothed grasping forceps with automatic catch, (4) short sponge holder, (5) Kocher clamp, (6) McKenzie's tonsillotome, (7) plain double-ended tongue depressor, (8) mouth gag.

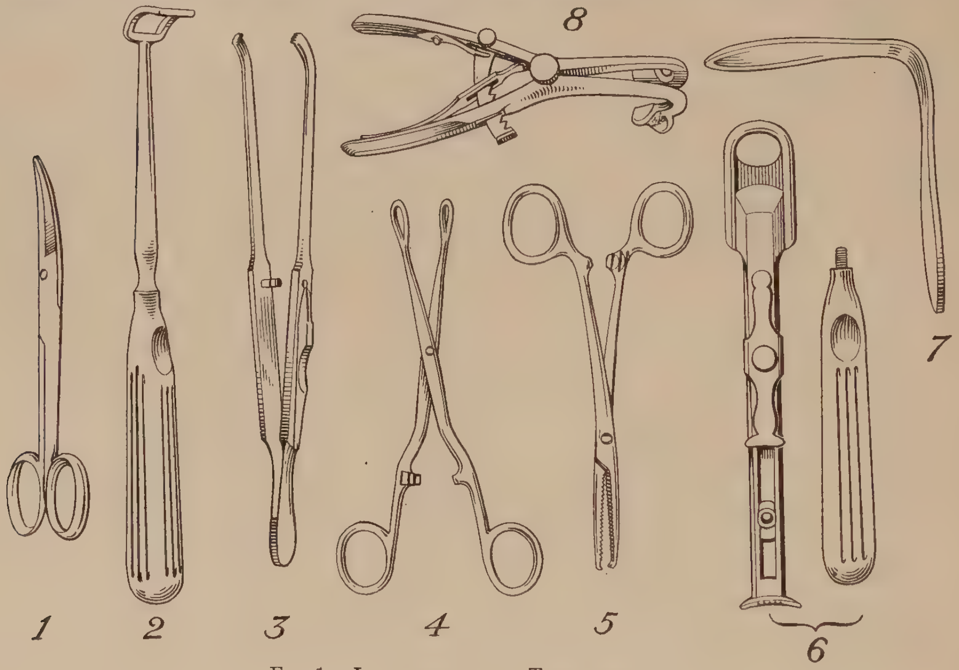


Fig. 1.—Instruments for Tonsillectomy.

These instruments should be of the best construction, with simple, strong locks, and made of the best materials. They will be found amply sufficient for the Mathews or the Sluder operations. For the latter the tonsillotome must be especially strong and well made, with a rather dull blade. For sight dissections with instruments the principal and only essential addition to the above is a nasal or pharyngeal insufflation apparatus of the Crile or Junker type. The Hitz instrument, combining mouth gag, tongue depressor, and pharyngeal insufflator, is very efficient and convenient. An aspirator for blood and mucus is very useful, but good sponging will suffice. If artificial light must be used, nothing is better than a good electric headlight. The vast array of special dissectors, curved, angled, sharp, and blunt, cannot be described in this brief article. They all seem superfluous. Skill and judgment are better than a multiplicity of instruments.

Most specialists still prefer the snare for the final step in removing the tonsil, and it is undoubtedly very efficient if properly used. Beck's tonsillectome is a good instrument, as is also Tyding's model with guide ring.

Anesthesia.—For children under 15 years, ether is the only anesthetic allowable. Chloroform cannot be too strongly condemned for throat operations. Nitrous oxid and oxygen are unsafe because of the ever-present danger of cyanosis. Ethyl chlorid resembles chloroform in its action and should not be used.

METHODS OF ADMINISTRATION.—For the rapid methods of operation, such as those of Mathews and Sluder, primary anesthesia induced by the drop method or with the old-fashioned towel cone is sufficient. For the sight dissection method continuous insufflation, nasal, pharyngeal, or intratracheal, and given by an expert, is the only safe procedure.

LOCAL ANESTHESIA.—Local anesthesia may be used in those over 15 years of age, provided neither the patient nor the operator is of a very nervous disposition. It is not entirely without danger. Ten per cent. cocain in a weak adrenalin solution should be swabbed thoroughly over the fauces, including the pillars, the soft palate, and the posterior pharyngeal wall. A half per cent. solution of novocain or 2 per cent. solution of quinin urea hydrochlorid should then be freely injected into the pillars, the capsule of the tonsil and the extratonsillar space. Great pains must be taken that none of the strong cocain solution is swallowed.

Position of the Patient.—When local anesthesia has been used the upright position or semireclining position is proper, although there is no valid objection to the reclining position. For work under general anesthesia the reclining position is the only safe one. Putting an anesthetized patient in the upright position cannot be too strongly condemned. It is little short of malpractice if chloroform is used in this position.

OPERATIVE TECHNIC

Mathews' Finger Enucleation.—With the patient under primary ether anesthesia in the dorsal position, head slightly extended and turned toward the operator, and the head of the table slightly lowered, the anesthetizer inserts a mouth gag and separates the jaws about 1½ in. This must be done gently but firmly in order not to injure the lips or tongue nor to loosen the teeth. A good way is to insert the index finger behind the teeth and force the jaws apart until the gag can be easily inserted on the side away from the operator. The latter then inserts his clean but ungloved left forefinger, palpates the tonsil on his side, determining the sharp lateral margin of the anterior pillar, and feels upward until a weak spot is found at the upper anterior angle, the plica triangularis. Crooking the finger well beyond a right angle, a gentle but firm stroke is made, pressing upward and outward with the pulp, not the nail, until the mucous membrane is felt to yield. This is the whole secret of success in finger enucleation. Rough or careless work at this stage is sure to result in excessive laceration of the pillar or the tearing of the tonsil substance. Properly done there should be no more traumatism of the tissues than with the most painstaking instrumental dissection. It undoubtedly requires skill of no mean order to find this weak spot quickly and by touch alone, but this skill is quickly attained by anyone having moderate surgical training, a reasonable knowledge of the surgical anatomy, and a desire to learn. Without these qualifications no one is justified in attempting tonsil work. Certainly instrumental dissection requires an equal or greater amount of skill and training.

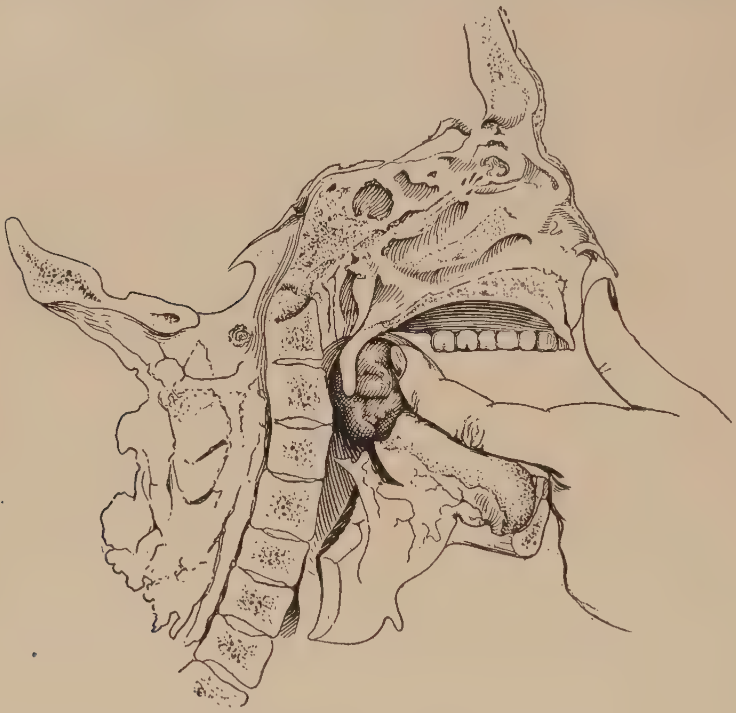


Fig. 2.—Separation of Anterior Pillar.

Once the finger dissection is started correctly, the remainder is very simple indeed. The line of cleavage opened up can be followed by the most inexperienced operator. The finger is passed rapidly between the anterior pillar and the tonsil, then upward over the upper pole, and the tonsil is stripped from the posterior pillar by forcing it downward until it hangs free in the throat by its vascular pedicle. Some care is necessary to avoid tearing the surrounding muscles, but if one works parallel to the muscle fibers no serious damage will be done. The tonsil may now be removed in any one of several ways. The simplest but not the easiest is to seize it with the thumb and forefinger and twist it from its bed. Considerable force is required and the mucous membrane at the base of the tongue may be torn. The tonsil is quite elusive at this stage of the operation and very slippery, so that it is easier to bring it forward onto the base of the tongue with the left forefinger and grasp it at its tip, the superior pole in the natural position, with a long toothed forceps or a Kocher clamp. A part of the capsule as well as tonsil tissue must be grasped to avoid tearing out, as the tonsil substance is rather friable.

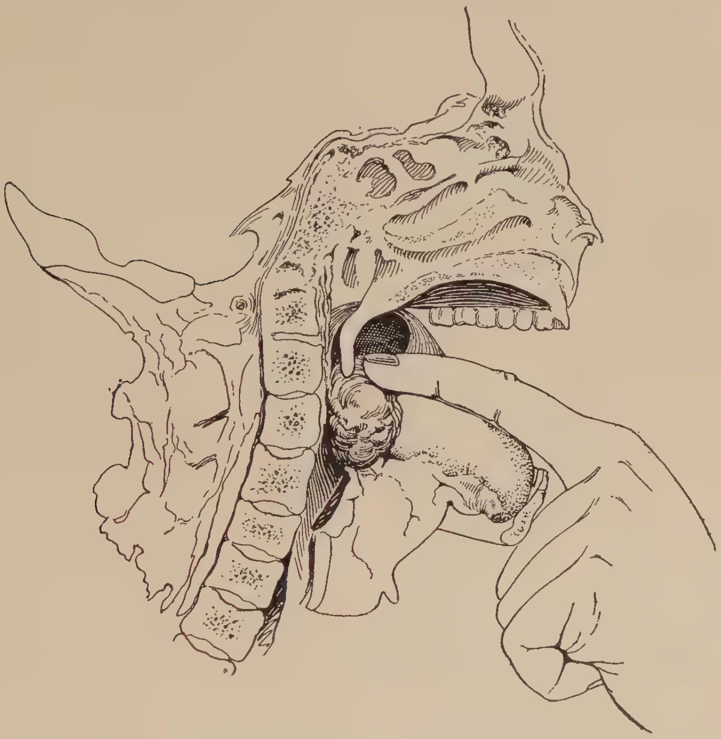


Fig. 3.—Enucleation Completed.

After the tonsil is securely grasped it may be removed by cutting across the pedicle with a pair of curved scissors, or better by the use of a snare or tonsillotome threaded over the clamp. I use a Kocher clamp passed through the ring of a McKenzie tonsillotome and have found it very satisfactory. The advantages of the snare are largely theoretical, and in the hands of any but an expert it is a clumsy instrument for rapid work. It will cut an improperly freed tonsil in two about as readily as will the tonsillotome and, as ordinarily used, has little or no hemostatic power. Unless 3 to 5 minutes is taken for crushing each pedicle, the knife or scissors might as well be used. If the tonsillotome is used the tonsil should be drawn well over toward the opposite side of the throat, the ring of the instrument pressed outward firmly against the body of the lower jaw, and the shaft carried across the mouth until it forms an angle of 45° with the jaw. In this way there is no danger of cutting the anterior pillar, while at the same time the base of the tonsil is completely removed. If the snare is used the loop must be pressed home around the pedicle and held there while it is being drawn tight. Hemorrhage is slight by either method and may usually be disregarded by a rapid operator. If necessary, the mouth and throat may be cleared of blood and mucus by sponging once, firmly but quickly, with a large pad of gauze. There is no time by this method for examination of the throat at this stage of the operation.

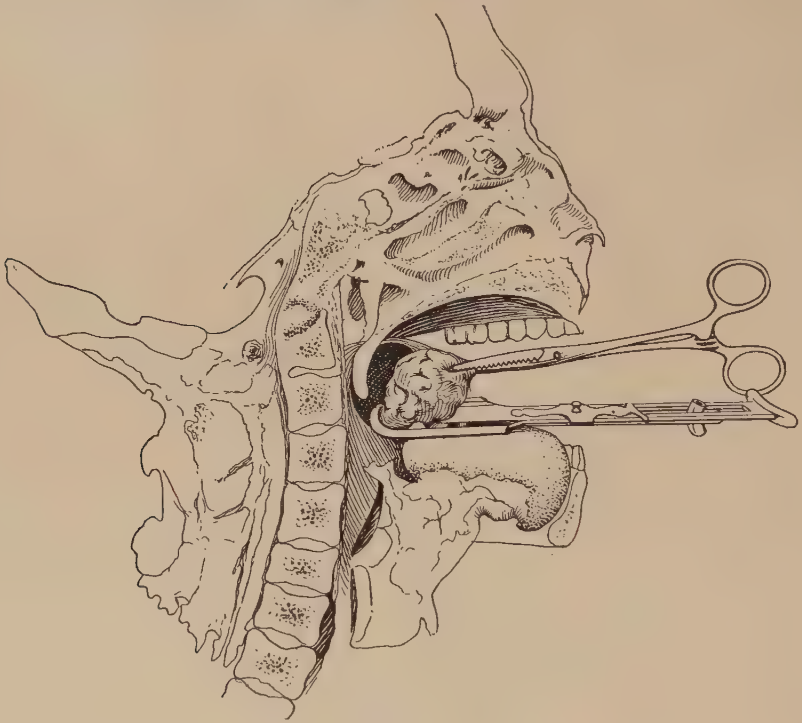


FIG. 4.—CUTTING THE PEDICLE.

With the first tonsil removed the gag is shifted to the opposite side and the second tonsil attacked in the same manner, again using the left forefinger for the dissection. Sponge once, if necessary, and proceed to the removal of the adenoids. Care must be taken not to injure the teeth in shifting the gag. If the jaws are set, merely touch the fauces with any instrument and they will relax, as the patient is rapidly regaining his reflexes. When the adenoids are out remove the gag and turn the patient on his side. He will expel his own blood and mucus, and the bleeding will be much less than if sponging is attempted with its concomitant gagging and cyanosis.

Squeeze the anterior nares to express any clots, as this will give a better airway.

After 2 or 3 minutes' rest insert the gag once more, sponge the throat firmly, and examine the result of the operation. If any loose tabs of mucous membrane or of tonsil are seen, they may easily be pulled off with the Kocher clamp or a sponge holder. Examine especially at the base of the tongue, as this is where a portion of tonsil is frequently overlooked. If any spurting vessel is seen it should be clamped with the Kocher clamp, which may be left on for 5 minutes and removed without further sponging. Ligatures are rarely needed. If bleeding still persists, the vessel may be clamped again and a suture tied about its base, or, better, press a small gauze sponge into the cavity with the index finger and hold it there firmly for 10 minutes. This will stop almost any hemorrhage. Great care must be taken to give a free airway, as cyanosis will almost surely start up renewed bleeding from other vessels. As a final measure, in obstinate cases, suture the pillars over a small plug of gauze. This will suffice for all but hemophiliacs, in whom blood-serum must be given subcutaneously in large quantities or a transfusion performed. If all these measures fail, the external carotid on the affected side must be ligated, or the common carotid, if very profuse hemorrhage indicates that the internal carotid has been injured. In the vast majority of cases, however, the bleeding is of venous origin, and can be easily controlled by simple gauze pressure.

ADVANTAGES OF FINGER ENUCLEATION.—The advantages of the finger method are many. Very little ether is used and an expert anesthetist is not essential. No special light is needed, as the operation is performed entirely by the sense of touch except for one look at the end of the procedure. No expert assistant is needed; the anesthetist simply holds the mouth gag. With operators of equal skill, traumatism by this method will not exceed that of any other, nor will hemorrhage. Shock will be less than by the dissection method with its prolonged anesthesia. Inhalation pneumonia is less probable.

Sluder Method.—The Sluder method requires only a very strong tonsillotome with a rather blunt knife. The operator, standing at the side of the patient in the usual position, attacks the opposite tonsil. The ring is passed over the base of the tonsil first, and it is absolutely essential to the success of the operation that the entire base of the tonsil is engaged. The tonsil is then drawn upward and forward onto the inner surface of the mandible, the shaft of the instrument being carried well to the operator's side, and by a combination of pressure of the instrument and counterpressure with the forefinger of the disengaged hand the tonsil is forced through the ring. The blade is then slowly sent home, making sure that every portion of the tonsil is entirely through the ring and that at the same time the anterior pillar is not. The blade may be felt passing over the tip of the forefinger, separated from it only by the thickness of the pillar. Considerable skill must be exercised in this maneuver, as one may easily punch a hole in the anterior pillar or, on the other hand, a large portion of the superior pole of the tonsil may be left behind. If the blade is too sharp, the tonsil will be merely shaved, while if it be not well made, the operation can only be completed by much tearing and twisting, with considerable danger to the surrounding structures.

In the originator's hands the Sluder operation has been successful in nearly all cases, but in mine, and, so far as can be judged from the literature, in the hands of others, complete success is attained in only about 60 per cent. of the cases. The rounded, protruding tonsils, even although well buried, are easily removed by this method, but the flat, soft or very fibrous ones are difficult, especially if the pillars are infiltrated.

The Beck tonsillectome consists of a powerful snare with a rigid ring guide. It is a useful instrument for performing the Sluder operation, but appears to fail in the same class of cases. The flat, soft, fibrous or infiltrated tonsils can only be removed by some form of dissection.

Instrumental Dissection of the Tonsils.—Instrumental dissection of the tonsils is not a very difficult operation to one familiar with the work. To perform it well three things beside the skill of the operator are necessary, perfect anesthesia by the nasal, pharyngeal or intratracheal insufflation methods, a skilled assistant, and perfect lighting of the field. With his trained "crew" and all the facilities mentioned, a good operator can unquestionably remove the tonsils completely and in good style. The operation is usually performed as follows: With the patient in the dorsal position, head to one side, or in the Rose position, the tonsil is seized with forceps if possible and drawn toward the opposite side, the tongue being well depressed and the field well exposed and lighted. The plica triangularis is incised with a knife or scissors at its anterior border, allowing the tonsil to be drawn partly from its bed. A curved blunt instrument or the tip of the forefinger is inserted in the exposed space and passed rapidly above and external to the tonsil, which can then be readily stripped from its bed and from the posterior pillar until it lies free in the throat on its vascular pedicle. The operation is completed by the snare, taking plenty of time and making certain that the loop is well placed. Bleeding points are clamped and tied if necessary, or some form of tonsil hemostat is pressed into the cavity. The opposite tonsil is then removed in a similar manner.

There are many ways of dissecting the tonsil but the principle of them all is incision of the plica triangularis and blunt dissection for the rest, either with the finger or some special form of blunt instrument. It is decidedly not an operation for the beginner to perform without supervision.

It is far more difficult than the Mathews or Sluder operation and does not offer corresponding advantages. Enucleation of the tonsil is not unlike enucleation of the prostate in many respects, and just as sharp dissection of the latter by the perineal method has been almost universally abandoned for the blunt suprapubic method, so in all probability, sharp dissection of the tonsil will be given up for the safer, quicker and easier blunt method. The tendency of all surgical technic is away from the knife and toward the blunt following of natural cleavage lines.

COMPLICATIONS AND RESULTS OF OPERATION

Dangers.—Aside from the dangers of hemorrhage, shock, and inhalation of blood and mucus, there remains the possibility of injury to the uvula, the pillars and the tongue. If the right cleavage plane is found at the beginning and followed with ordinary care, no difficulty should be experienced except in the infiltrated cases. These are not easy by any method, and only the skill attained from long practice will obviate an occasional injury to the anterior pillar or failure to remove the entire tonsil.

The operation of tonsillotomy and the punch method will not be considered in this article, as they are almost entirely superseded by the more modern operation of enucleation. In passing, however, it may be said that even the most expert operator will have occasion to use the punch at times in the post-operative period or later. Tonsil tissue probably never recurs in the technical sense, but it has the disconcerting habit of appearing occasionally where it ought not to be.

Complications.—The principal complication of tonsillectomy is sepsis. The cavity left by operation must heal by granulation and all cases are infected to a greater or less extent. Drainage is good, however, and in general the reaction to operation is slight. The subparotid nodes swell occasionally but suppuration is uncommon. General sepsis is a possibility but must be very rare. A complicating scarlet fever or erysipelas, although very rare, is apt to be fatal.

Hemorrhage, immediate or delayed, is the most common complication. It usually takes the form of venous oozing but may be arterial. Prompt recognition is essential. Treatment consists of wiping out the clots, firm gauze pressure, clamping and ligating the bleeder, or suture of the pillars over a plug of gauze. It cannot be too strongly emphasized that a child will at times bleed even to a fatal issue without visible signs of hemorrhage. Constant watchfulness is the only safeguard. The usual treatment of shock must be instituted after the bleeding has been checked, not forgetting hypodermoclysis and the rectal drip of warm water.

Immediate Results.—The immediate results of tonsillectomy are a sore throat, with more or less severe systemic reaction and pain behind the ears and on swallowing. If the pillars have not been traumatized, the local reaction is usually slight, a pseudomembrane forming in the tonsil bed and healing taking place in a week or 10 days. If the pillars have been torn, healing is considerably delayed. No great harm seems to follow removal of the anterior pillar, although the patient may complain that his tongue is tied to the roof of his mouth. Without the support of the tonsil the pillar usually fades out gradually into the mucous membrane of the mouth. Injury or removal of the posterior pillar is said to result in more or less serious impairment of the singing voice.

Remote Results.—The remote results of operation are excellent, provided an efficient operation has been done, with good indications. The benefit is great and, moreover, lasting, locally and systematically as well. I speak feelingly from personal experience, as well as from a fairly extensive experience in which there has been no fatality, no serious complication, and no bad results except some imperfect enucleations and a few injuries to the pillars, due to lack of skill and care.

REMOVAL OF PHARYNGEAL ADENOIDS

Indications.—The indications for the removal of adenoids are as follows:

(1) Obstruction to normal breathing, as evidenced by mouth breathing, either diurnal or nocturnal, snoring, night strangling and crying, excessive drooling, breathing difficulties during nursing or the swallowing of food.

(2) Inflammatory symptoms, such as frequent sore throats, colds in the head, coughs, running nose, repeated otitis media, and finally, but not least important, repeated or chronic enlargement of the lymph nodes at the angle of the jaw. It is good practice, also, to feel for and remove any adenoid growth during the operation for tonsils, or any other minor procedure.

The adenoid countenance, high-arch palate, irregular teeth, and other structural changes are secondary to obstructed nasal breathing, may be due to other causes than adenoids, and may persist after the removal of adenoids even if they were the exciting cause. Many needless operations are done because of the lack of a careful examination and from slovenly diagnosis. The mere presence of adenoids, without obstructive or inflammatory signs, is not an indication for operation.

The contra-indications are the same as for tonsillectomy.

Anatomical Points.—The pharyngeal tonsil is a mass of adenoid tissue lying back of the soft palate, between the Eustachian tubes, and extending from the base of the occiput to the lower edge of the axis, being separated from the bone by the pharyngeal aponeurosis and the superior constrictor of the pharynx. It varies greatly in shape, from the flat and fibrous to the rounded and soft protruding mass. Similar but smaller patches of lymphoid tissue are to be found scattered all over the pharynx and even the posterior surface of the posterior pillars of the fauces, from which it may readily be seen that the complete removal of adenoid tissue from the throat is an impossibility. The points of surgical interest are the posterior edge of the vomer above, the internal openings of the Eustachian tubes on either side, and the uvula in front.

Instruments.—Many instruments have been devised for the removal of adenoids, but the Beckman curet is sufficient. Its cutting edge must be sharp. A small sponge stick is useful in removing any tabs. The operation can be performed without an anesthetic or under local anesthesia, but a general anesthetic is to be preferred for children. The preparation is as for the removal of tonsils.

Operative Technic.—With the patient in the dorsal position, except when local anesthesia is used, in which case the upright position is allowable, and with the head moderately extended, a mouth gag is inserted and the jaws widely separated. The operator's left forefinger is passed into the nasopharynx and the uvula hooked out of the way. The curet is then inserted until the vomer is felt, its handle being depressed as far as possible. With one quick downward sweep of the curet the main mass of adenoids is removed and is brought out clinging to the instrument. A dull curet or too light pressure will only bruise the adenoids. Too great pressure will cause injury to the pharyngeal aponeurosis, or even the vertebræ. The same maneuver is repeated on either side of the median line, pressing the curet well over into the lateral sulci. Then pass the forefinger well up into the posterior nares on either side and feel for any remaining bits of adenoid tissue. These may also be removed with the curet. Sponge once firmly with a large gauze wipe and examine with the eye for any tabs of adenoid hanging in the throat. These may be pulled off with the sponge stick or removed with any one of the numerous adenoid forceps. It is not good practice to wipe out the nasopharynx with gauze dipped in alcohol or any other chemical, as it will only tend to the production of more raw surface in places where it should not be, to increased inflammatory reaction, to irritation of the Eustachian tubes and otitis media, or to the formation of very troublesome adhesions. The purpose of this gauze scrubbing is to remove any shreds of adenoid tissue and to stop hemorrhage, but, as a matter of fact, the bleeding will cease very quickly without treatment and the fragments of tissue will slough off if not removed by the curet.

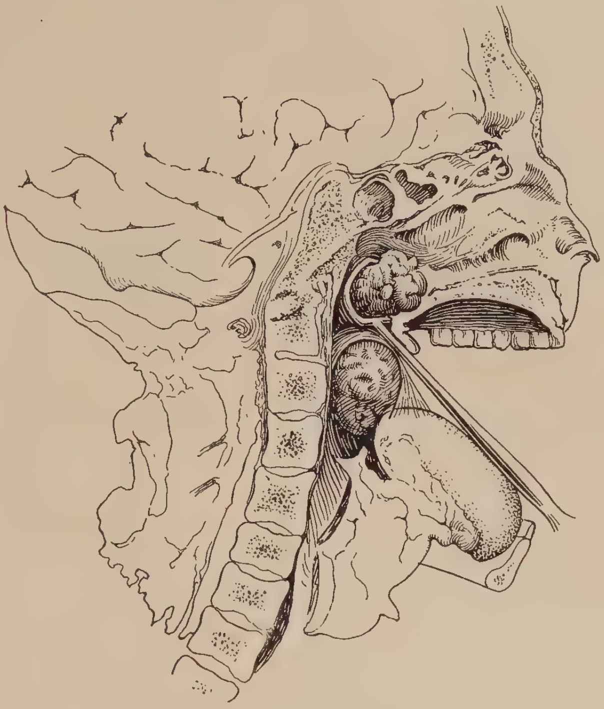


Fig. 5.—Removal of Adenoids.

Dangers of Operation.—The dangers of the operation are from the aspiration of blood and mucus. If the procedure is carried out quickly and the child is promptly turned on its face there is very little danger of aspiration. Aside from this, there is always the possibility of cutting off the uvula by clumsy work or of injuring the vomer, the vertebræ, or the Eustachian tubes by too vigorous use of the curet. This is quite likely to follow the careless use of the adenoid forceps. Prolonged suppuration may follow an injury to the bone, but no serious harm seems to ensue. Injury to the Eustachian orifices is not a trifling matter, however, and for that reason the use of the small ring curet in this region is not advisable.

Complications.—The chief complication of the operation is otitis media, usually a recrudescence of an old condition. Acute septic meningitis and death have been known to follow. The aspiration of blood and mucus may lead to bronchopneumonia or to pulmonary gangrene and abscess. Scarlet fever or erysipelas may occur with a possibly fatal issue.

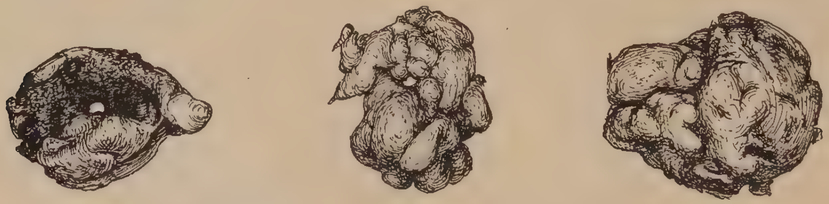


FIG. 6.—SPECIMENS OF TONSILS AND ADENOIDS REMOVED.

Operative Results.—The results of the removal of adenoids in young children, before bone deformities have occurred, are excellent, provided the operation was indicated. Inflammatory symptoms are markedly relieved and the possibility of nasal breathing is restored, while, in time, glandular swellings at the angle of the jaw usually subside if not of a tuberculous nature. In older children and adults with fixed habits of mouth breathing and with well-developed structural changes, it is not rational to expect a complete return to normal, nor does such occur. They at best require additional treatment, operative or otherwise, for the correction of structural deformities.

AFTER-TREATMENT OF ADENOID AND TONSIL CASES

The after-treatment in tonsil and adenoid cases is very simple. Liquids in small amounts, frequently repeated, may be allowed after 2 hours, and soft diet the following day. One day in bed is usually sufficient if no complications ensue, but dust and drafts must be avoided for at least a week. No local treatment in young children is advisable except a drop of mentholated albolene (½ per cent.) in each nostril several times a day. Older children and adults may use the same in an atomizer, along with any bland or soothing gargle. The pain is quite severe and may require the use of codein or morphin. Cold applications to the neck are helpful.

REMOVAL OF THE LINGUAL TONSIL

The lingual tonsil rarely requires operative treatment. It may be removed by suitably curved punch-forceps, or by a curet. Ordinarily the application of astringents or caustics is sufficient to relieve symptoms.

PERITONSILLAR ABSCESS

Peritonsillar abscess is frequently inefficiently treated. Blind punctures in the region where the pus ought to be, more or less probing, and then a wait of a day or 2 for the abscess to ripen, is the usual course of events. Where the abscess is definitely pointing, puncture and dilatation of the opening are efficient, but in the small, blind cases it is much better to insert the tip of the forefinger or a curved blunt instrument behind the anterior pillar and separate it from the tonsil. In a fairly large number of cases I have never failed to find the pus just external to the tonsil. The procedure is very painful, requiring the use of a whiff of nitrous oxid in the case of small abscesses. The work must be done in the stage of analgesia after consciousness has returned, as aspiration of pus would be extremely dangerous. Drainage by this method is perfect, and there is very slight liability to the formation of other pockets. The tonsil is practically enucleated and may be easily removed if one is prepared to do so. This has been done in a considerable number of cases, all with good results.

The treatment of *tumors* will not be considered in this article. They are usually extremely malignant and, if operable, require the most extensive dissection of the tissues of the neck and throat. No operation of the enucleation type is permissible.

THE THYROID

CHAPTER VII

THE THYROID

EUGENE H. POOL

The surgery of the thyroid gland is the prototype of the surgery of the glands with exclusive internal secretion. Not only was the thyroid the first of the ductless glands to warrant operative interference, but, by reason of its accessibility, the frequency of its lesions and the relatively well-defined evidence of its malfunction, it has come to offer an ever-increasing field of fruitful surgery. However, in spite of the marked progress in our knowledge of its pathology and of the surgical indications and operative treatment of its lesions, many perplexing features bearing on the subtleties of its internal secretion are still attached to the study of the physiology of the gland.

The history of the surgery of the thyroid is peculiar in that it has enjoyed a relatively rapid development through the efforts of comparatively few men; a review of its surgery, therefore, comprises for the most part a summary of the work of a small number of eminent operators and thinkers who have been largely responsible for the great advances which have led to the brilliant results attending thyroid operations. Among the conspicuous contributors may be mentioned Billroth, the Kochers, Reverdin, von Eiselsberg, C. H. Mayo and Halsted. An effort will be made to ascribe to the proper sources well-defined improvements in technic, but this cannot always be done, as notable developments in the work of various surgeons have often run parallel or been synchronous, so as to render it difficult or impossible to specify priority. A general acknowledgment and tribute, therefore, to these and other leaders in this field must replace oft-repeated specific references to their work.

ANATOMY OF THE THYROID AND PARATHYROID GLANDS

THE THYROID

Thyroid Gland Development.—The thyroid gland appears in the third week of fetal life as an epithelial outgrowth from the wall of the primitive pharynx between the buccal and pharyngeal origins of the tongue. This mass of tissue grows downward in the ventral wall of the neck forming the thyroglossal duct. At about the end of the second month the lower extremity bifurcates, forming what later becomes the isthmus and lateral lobes. The assumption which prevailed until recently, that the gland was developed from one median and two lateral anlages with final union between these parts, has been generally abandoned. With the bifurcation, the duct tract as a rule disappears, leaving a slight depression on the tongue, the foramen cecum, just behind the apex of the V-shaped row of the circumvallate papillæ (Piersol). Occasionally part of the duct persists. Isolated portions may undergo changes resulting in cysts, which are sometimes found in the adult in the course of the duct (Keibel and Mall, Bailey and Miller).

General Characteristics.—The thyroid gland in man is composed of two lateral lobes united by an intervening bar, the isthmus. The isthmus occupies a transverse position overlying approximately the second, third, and fourth rings of the trachea, to which it is firmly attached by fibrous tissue. The lateral lobes, one on each side, lie close to the trachea and larynx.

The gland is of a bluish red color, very vascular and weighs about 30 to 40 grams. Each lobe normally measures about 2 in. in length, 1¼ in. in breadth, and ¾ in. in thickness. The lobes are roughly pyramidal in shape, and for descriptive purposes, although somewhat arbitrarily, may be said to present 3 surfaces, external, internal, and posterior. These surfaces come together in a rounded apex and a thick rounded base. The gland is enveloped in a thin fibrous capsule, the "true" or anatomic capsule. Connective tissue strands from the inner surface of this capsule penetrate and subdivide the gland.

Blood Supply.—The gland receives its blood supply from 5 sources:

Two superior thyroid arteries.

Two inferior thyroid arteries.

One thyroidea ima artery, which is present in about 10 per cent. of cases.

The *superior thyroid artery* arises from the external carotid, near its origin. It curves downward, forward, and inward, passing under the anterior edge of the sternomastoid muscle and beneath the anterior belly of the omohyoid to the upper pole of the gland. Near the gland it divides into 2 branches, anterior and posterior. The anterior, larger branch, passes along the mesial border of the lobe to the isthmus, giving off terminal anastomosing branches. From it frequently arises a relatively large branch to the pyramidal process. The posterior branch usually enters the upper pole, but at times passes downward upon the posterior surface before entering the gland.

The *inferior thyroid artery* arises almost always from the subclavian artery through the thyroid axis. It passes vertically upward to about the level of the sixth cervical vertebra, then bends behind the carotid sheath, passes in front or behind the recurrent laryngeal nerve, and divides close to the gland into two terminal branches. "In 437 observations the artery was found in front of the nerve on the right side in 41 per cent. and on the left in 63 per cent.

In over 10 per cent. of the cases the branches were so interlaced that the relation was uncertain." (Piersol.)

Thyroidea ima artery, present in about 10 per cent. of cases, is a branch of the innominate which runs along the trachea to the isthmus.

The main branching of the thyroid arteries is chiefly on the surface of the gland, the smaller branches entering it. Anastomoses between the vessels are very free.

Veins.—The main veins of the thyroid are: superior thyroid, middle thyroid, and inferior thyroid. The superior thyroid veins, 1 or 2 on each side, leave the upper pole of the thyroid body and ascend to join the internal jugular or common facial vein. A middle thyroid vein in the average case issues from each lateral lobe of the thyroid, crosses the common carotid artery, and enters the internal jugular. This vein is extremely variable in position; moreover, it may be absent or may be represented by several veins. The inferior thyroid veins are of large size; they are formed by branches from the isthmus and lateral lobes of the thyroid. Their course is variable, but in general they descend along the trachea to the innominate trunks. At times they form a plexus on the front of the trachea below the isthmus of the thyroid. All these veins anastomose freely.

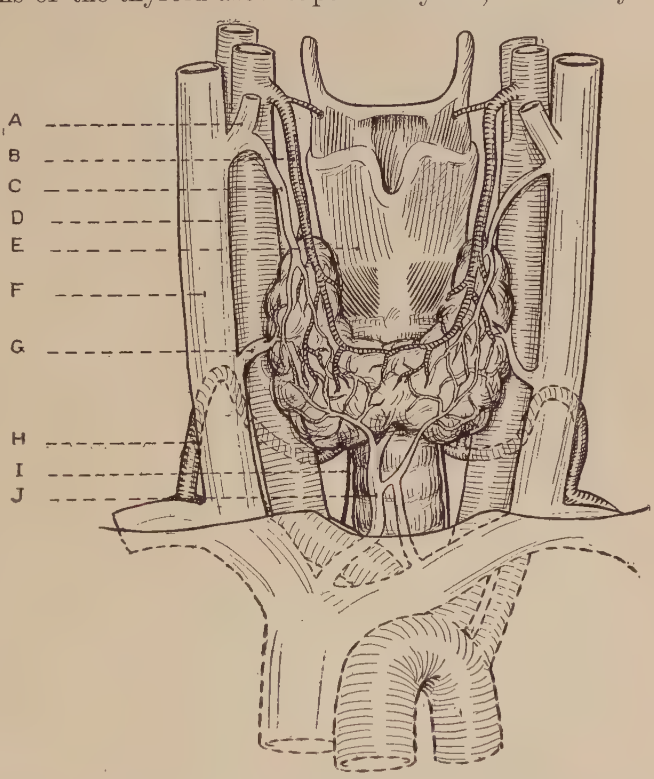


Fig. 1.—Diagrammatic Representation of the Relations of the Thyroid Gland and Its Vessels. A, Facial vein; B, superior thyroid artery; C, superior thyroid vein; D, common carotid artery; E, thyroid cartilage; F, internal jugular vein; G, middle thyroid vein; H, inferior thyroid artery; I, recurrent laryngeal nerve; J, inferior thyroid veins.

Lymphatics.—"Plexuses are formed by the lymph-vessels, which unite to form small trunks on the surface of the gland, especially the anterior median portion of the lobes. This lymphatic network becomes much enlarged in large colloid goiters" (Kocher). The collecting trunks follow the general course of the veins and empty into the superior and inferior cervical and upper mediastinal nodes.

Capsules.—The thin fibrous tissue envelope which incloses and forms part of the gland may be termed the anatomic capsule. Between it and the surgical capsule is a layer of loose connective tissue. The surgical capsule or the "external thyroid capsule" (Kocher) is a thin layer of the deep cervical fascia which surrounds the gland. It is formed as follows: The layer of cervical fascia which splits to inclose the sternomastoid muscle gives off from its deep surface one or two fascial layers which inclose the great vessels and form their sheath. From the mesial aspect of the vessel-sheath several processes arise. One passes anteriorly in front of the thyroid, and joins the similar layer of the opposite side. This layer extends upward from the isthmus and adjacent portions of the thyroid to the cricoid and lower border of the thyroid cartilage, forming a distinct band called the anterior thyroid ligament. Another process from the vessel-sheath passes posterior to the thyroid and splits into two layers, the anterior of which lies in contact with the posterior surface of the gland and is inserted into the posterior portion of the external surface of the trachea; the posterior passes behind the esophagus and forms the prevertebral fascia. As a result of the fixation of the thyroid to the trachea by the external capsule, the thyroid gland moves with the trachea during the act of swallowing. In the external thyroid capsule are a large number of veins, *venæ accessoriæ* (Kocher). The recurrent laryngeal nerve, lying in the groove between the esophagus and the trachea, is embedded in the external capsule.

Nerve Supply.—"The nerves of the thyroid gland accompany and surround the blood vessels; they are derived from the superior ganglion of the sympathetic and from the superior and inferior laryngeal branches of the pneumogastric. No secretory fibers have as yet been demonstrated" (Kocher).

Anatomical Relations.—Anterior to the gland, on each side of the median line, is the sternothyroid muscle, in front of which is the sternohyoid. Running diagonally across the upper part of the sternothyroid is the anterior belly of the omohyoid. The sternal origins of the sternomastoid muscles cover the lower parts of these muscles and also part of the lateral lobes of the thyroid. The anterior jugular veins pass from above downward on each side of the median line within the fascial layer which lies between the platysma and the depressor muscles.

Posteriorly and mesially the gland embraces the upper end of the trachea and part of the larynx. The isthmus usually lies on the second, third, and fourth tracheal rings. The lateral lobes extend downward as far as the sixth ring, upward to the middle third of the thyroid cartilage, and backward as far as the esophagus. Posterior to the lower part of each lateral lobe lie the inferior thyroid artery and recurrent laryngeal nerve, and behind the upper pole is the posterior branch of the superior thyroid artery. The parathyroids also lie behind the lateral lobes; their positions will be described later. External to the lateral lobes is the carotid sheath containing the carotid artery, vagus nerve and internal jugular vein.

When the thyroid enlarges, its relationship to neighboring structures

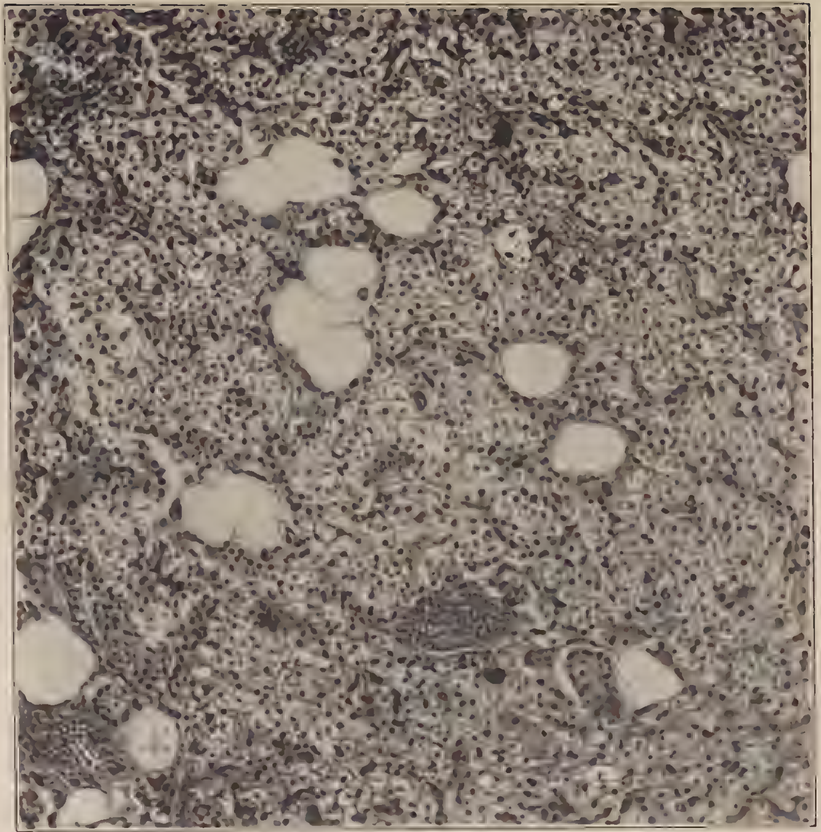


FIG. 2.

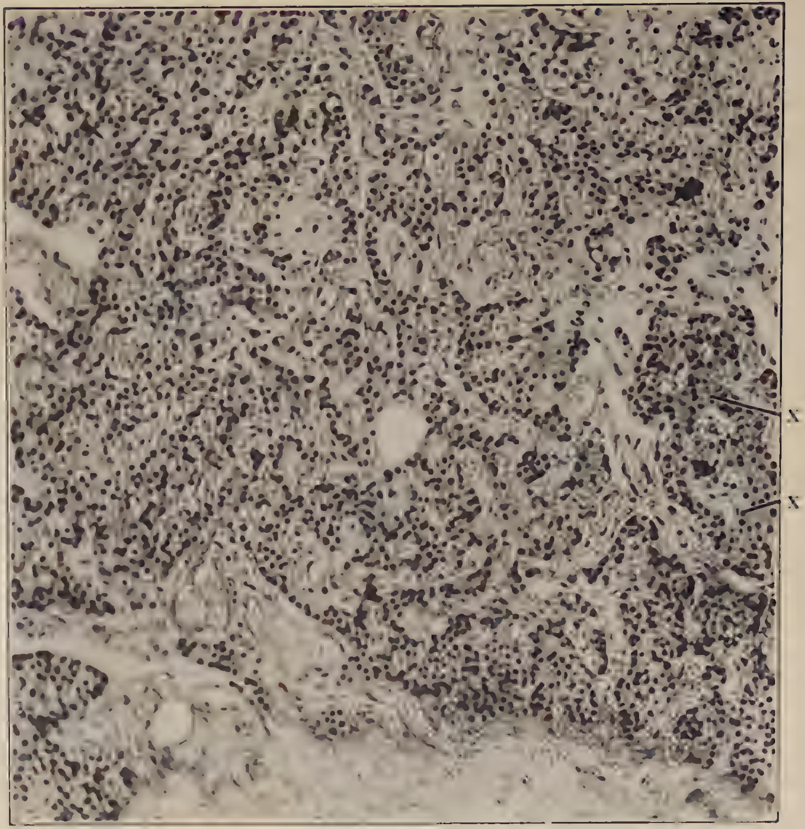


FIG. 3.

FIGS. 2 AND 3.—PARATHYROID TISSUE SHOWING VARIETIES AND DISTRIBUTION OF CELLS. In Fig. 2 principal cells predominate; in Fig. 3 masses of oxyphile cells may be seen (X).

changes. If enlargement is forward or upward, the goiter stretches and separates the muscles overlying it. If enlargement is lateral, the carotid sheath and its contents are displaced. In a large goiter the artery may be pushed outward behind the vein while the vein becomes spread out upon the side of the tumor or may even lie upon its anterior surface. In extreme cases the artery and vein may be separated by a considerable interval, the vein lying in front of and nearer the median line than the artery. Hence it does not follow that the pulsation of the artery will necessarily indicate the position of the vein. A knowledge of the possibility of this altered relation is essential. Lücki gives the following explanation: Veins which pass from the thyroid to the internal jugular limit the displacement of the latter, whereas the artery is not similarly restricted. The position of the recurrent laryngeal nerve may be altered by the growth. Ordinarily it is pushed backward and inward and lies in the furrow between the trachea and esophagus; rarely it is spread out over the posterior surface of the tumor.

Anomalies of the Thyroid Gland.—In rare cases one lobe or even more of the thyroid is absent; the isthmus is absent in about 10 per cent. of cases (Piersol). A pyramidal process, occasionally double, is present in about 50 per cent. of cases. It is an elongated mass of thyroid tissue projecting upward from the isthmus lying in or near the mid line. It may reach as far as the hyoid bone.

Accessory thyroids are isolated masses of thyroid tissue of variable size which occasionally occur in the neck in addition to the normal thyroid body. They are really supernumerary thyroids. When connected with the thyroid gland, they are termed pseudo-accessory thyroids; when at a considerable distance from the thyroid, they are termed aberrant (wandering) thyroids. They are found chiefly in the following regions: superiorly, along the track of the obliterated thyroglossal duct; inferiorly, within the mediastinum; laterally, between the carotid sheath and the lateral lobe. Aberrant masses are also found in a variety of other positions, such as the submaxillary region. Accessory and aberrant thyroids may present the same lesions as the thyroid itself. Of particular surgical importance in connection with accessory thyroids are those which occur in the tongue and those which give rise to intrathoracic goiters.

THE PARATHYROID BODIES

The parathyroids or "epithelial bodies" (Kohn) are branchial cleft derivatives. In man and most mammals they develop from the third and fourth branchial clefts of each side as masses of compact epithelial cells. They are as a rule 4 in number, but their exact enumeration in an individual case is often difficult because of their small size, variable position, and similarity in gross appearance to other tissues.

Histologically these organs consist of a mass of cells (Figs. 2, 3) invested with a thin fibrous capsule. The gland has a reticular stroma and is strikingly vascular.

The occurrence of the glands in pairs is the typical arrangement, a superior (external) and an inferior (internal) body being present on each side. The following are the most frequent situations, although variations from these positions are frequent. The superior lies close to the thyroid on the middle third of its posterior surface, approximately on the level of the lower border of the cricoid cartilage. It lies on a plane posterior and external to the terminal branches of the inferior thyroid artery and recurrent laryngeal nerve.

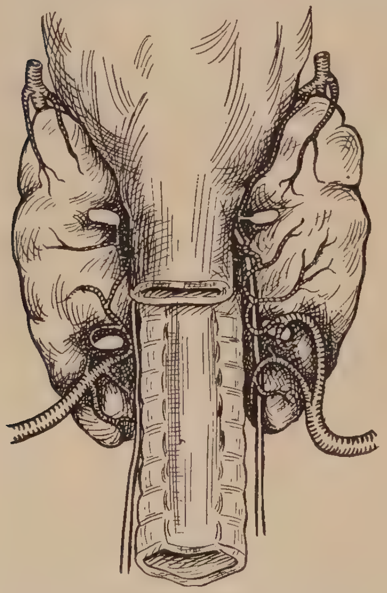


Fig. 4.—Posterior Aspect of Lateral Lobes of Thyroid Showing Positions in Which the Parathyroid Glands Frequently Occur. The blood supply of the parathyroids is represented diagrammatically according to the description of Halsted and Evans.

The inferior lies most often on the posterior aspect of the lower third of the thyroid, in which case it is frequently found anterior to the recurrent laryngeal nerve and inferior thyroid artery, close to the thyroid gland at the entrance of the lower branches of the artery. The gland also may lie at or below the inferior pole of the thyroid.

Accessory organs, that is, small accumulations of characteristic parathyroid cells, have been found not infrequently, especially below the thyroid, within the thymus and even within the thyroid (Getzowa).

The parathyroid glands lie outside of the thyroid, from which they are separated by portions of the external capsule, yet one or more may be beneath this capsule, but rarely imbedded in the substance of the gland.

The size of the organ varies from about 3 mm. to 15 mm., the average being about 6 by 4 by 2 mm. (Berkeley). The bodies are usually somewhat flattened, and may be of various shapes, but especially round, oval, or reniform. The color is a peculiar yellowish brown.

The blood supply of the gland (Fig. 4) is described by Halsted and Evans as follows:

> "In practically every case studied, the lower parathyroid artery came from a prominent branch of the inferior thyroid artery. The actual number of observations was nineteen. The upper parathyroid gland invariably has a short artery of supply which may rise from one of the main branches of the inferior thyroid or from an anastomosing ramus joining the superior and inferior thyroid arteries. A very prominent anastomosing channel was found along the posterior margin of the lateral thyroid lobe in eight of twenty instances, and in these cases the superior parathyroid artery was a short branch from this channel."

HYPERTHYROIDISM OR THYROTOXICOSIS

Hyperthyroidism or thyrotoxicosis is "the constitutional state associated with goiter" and presumably due, in part at least, to thyroid intoxication. The terms include the toxemias at times noted in the course of simple goiter, as well as the systemic disturbances occurring in exophthalmic goiter. As Plummer states, the two conditions should be differentiated. To avoid confusion, we will use the term "exophthalmic goiter" instead of "hyperthyroidism" in the consideration of the condition about to be described.

EXOPHTHALMIC GOITER

General Considerations.—Exophthalmic goiter (Graves' disease, Basedow's disease) consists in a peculiarly variable group of symptoms, the chief of which are enlargement of the thyroid, exophthalmos, tachycardia, and tremor. With these are associated numerous others less striking and less characteristic, such as emaciation, muscular weakness, excitability and disturbances of the digestive organs and vasomotor system. Not only is the grouping of the symptoms exceedingly variable but likewise the order of their development. In a well-marked case all of the cardinal symptoms may be conspicuous and the diagnosis unquestionable; on the other hand, in early cases or incomplete (fruste) types of the disease the symptom-complex may be such as to render diagnosis difficult and perhaps only possible by an exceptionally acute and trained observer. Thus, we have the two extremes: the well-marked case with exophthalmos, goiter, tachycardia, tremor, emaciation, and the suggestive blood changes, and, in contrast to this, the case presenting few symptoms, such as tachycardia, emaciation, and muscular weakness, with doubtful or negative blood findings and no suggestion of enlargement of the thyroid or exophthalmos. Between these extremes there are all possible gradations and combinations of symptoms. The onset of the disease is usually relatively acute, and its course chronic, characterized by remissions and exacerbations.

The symptoms which comprise the disease were ascribed for many years exclusively to overactivity of the thyroid gland with increased production and absorption of its secretion, and upon this interpretation of the disease has been based its surgical treatment. But of late there has developed a feeling of opposition to this long-accepted theory, many observers being inclined to discredit the thyroid as the unique and all-important cause of the symptoms. Recent investigations seem to show a close connection in exophthalmic goiter between the thyroid and other organs. To persistence of the thymus has been attributed an important part in the pathogenesis of the disease, while various observers attach importance to the relationship which they consider has been established between the increased activity of the thyroid and the pituitary, pancreas, and chromaffin system, especially the adrenals. The investigations upon which these opinions are based are suggestive of findings which will modify the long-accepted interpretation of exophthalmic goiter. They point especially to the possibility that the thymus plays an important rôle throughout the course of the disease and that the symptom-complex is modified by concomitant functional derangements of other ductless glands, or is due to polyglandular hyperactivity or lack of balance. However, a pall of confusion is at present spread over the whole question of the origin of the disease. It is of vital importance that we should know what symptoms are due to hyperthyroidism, hypothyroidism, and dysthyroidism, and how and to what extent other glands modify these symptoms. Efforts are constantly being directed toward the solution of these problems by experimental pathological, physiological, and clinical studies. With greater knowledge more exact indications for treatment doubtless will be possible. But while investigators appear to be on the threshold of a more intimate understanding of internal secretions, and especially of their associated interactions, as yet facts bearing upon this phase of the subject are not sufficiently established to influence materially our practical attitude toward the operative treatment of the disease.

Before entering into considerations of treatment it is necessary to define the interpretation of the disease upon which are based the therapeutic measures advocated and practiced at the present time. Without going into the intricacies of the discussion, it may be assumed that in this disease the structure of the thyroid shows fairly definite changes from the normal, namely, hypertrophy and hyperplasia of the thyroid parenchyma; that the gland secretes an excess of normal or of perverted material which enters the circulation, causes toxemia, and secondarily influences the functional and organic conditions of other organs; that the usual type of the disease is represented by symptoms referable to this hyperactivity of the thyroid, modified, if at all, only to a minor degree by other organs, constituting for practical purposes a thyrotoxicosis or hyperthyroidism, and, finally, that the symptoms as a rule may be favorably influenced by operative measures limited to the thyroid. Such is the consensus of opinion among experienced surgeons; an opinion justified by results. It is likewise fair to assume that there is a smaller group in which the symptoms are due in part to hyperactivity of the thyroid, but are complicated to a marked degree by functional disturbances of other ductless glands. Whereas the first type is usually easily recognized, no definite rules can be formulated for the second. Therefore, this type must be disregarded unless it is suggested in the study of a case by irregularities of the symptoms which, when noted, should lead to caution in diagnosis and in treatment.

Operative Indications.—There has been much discussion as to the indications for operative interference in Graves' disease and great divergence of opinion has been expressed. So general an antagonism to and fear of operative treatment has been prevalent for many years that it is advisable at the outset to call attention to the factors upon which this feeling depends.

First, the cases have long been considered notoriously bad operative risks, and, in consequence, medical men have shown a disinclination to recommend operation. Second, numerous non-operative procedures, some empirical, others based upon scientific observation, have been exploited with much confusing theory and have been employed with more or less benefit, although they have not been successful enough to avoid many therapeutic disappointments. However, they have encouraged the point of view that operation should be employed only as a last resort. Third, the symptom-complex is so variable as to make it impossible, especially in mild cases, to construct exact rules whereby certain definite groups of symptoms can be designated as positively indicative of operative interference rather than medical treatment. Fourth, the present tendency to discredit the thyroid as the essential, unique, and all-important cause of the symptoms has been prone to favor other measures than operation on the thyroid for the treatment of the disease. Fifth, the permanence of operative results has been questioned.

While these views cannot be disregarded altogether, their importance has been unduly magnified; they have fostered an aversion to operation which has resulted in harm to many patients. As opposed to the above objections, it must be emphasized that too great weight has been attached to the operative danger, as is shown by the fact that the operative mortality in the hands of skillful surgeons has been reduced to about 4 per cent. Moreover, it is the consensus of opinion among experienced surgeons that, when a careful study of a case has demonstrated to a reasonable certainty that the symptoms are due in large part to increased activity of the thyroid gland, curtailment of the thyroid activity and secretion, through limitation of its blood supply or diminution of its secreting tissue, is the ideal therapeutic procedure, and that operation offers the most reasonable, reliable, rapid, and lasting means of improvement or cure.

As a matter of fact, both the operative and non-operative procedures are essential in the treatment of the disease. Efforts should not be directed toward exploiting one to the disadvantage of the other, but rather each should be accepted and an effort made to establish their respective indications and harmonize their uses.

It must be understood that the course of the disease is uncertain, and that occasionally, especially early in the disease, patients improve or recover without operation, at times without medical treatment. Consequently when cases are seen in an early stage, a trial of non-operative measures is advisable to avoid unduly precipitating the patient into operative risks.

But it should be understood that non-operative treatment rarely affords more than temporary improvement and usually requires periodic repetitions. If improvement is not strikingly marked and relatively lasting under medical treatment, operation is indicated unless definite contra-indications are present. Moreover, early operation is indicated and unnecessary delay by unduly protracted non-operative measures is to be condemned for the following reasons: The operative risk is much less in an early than in an advanced stage of the disease; the heart and other organs have not sustained permanent damage and, the course of the disease being usually progressive, it is probable in every case that operation will ultimately become necessary. In urging early operation, Kocher emphasizes its special importance in the steadily progressive, in contrast to the periodically progressive, types of the disease.

In a late stage or in acutely active periods of the disease a preparatory course of medical treatment is always advisable and often imperative, the aim being to improve the condition of the patient so that operation may be undertaken with comparative safety.

On the details of non-operative treatment we cannot dwell at length. The essential factors are, first, rest, and, second, food. By rest is meant absolute physical and mental rest; rest in bed for weeks, amid cheerful, care-free, and hygienic surroundings. Next in importance to rest is food; emaciation must be prevented or corrected; an abundant simple diet is therefore important. Massage, baths, and drugs should be employed as indicated. Drugs are chiefly indicated for their tonic effect (arsenic, iron) or sedative effect (bromids, quinin hydrobromate). Various therapeutic agents, such as extracts of thymus, pituitary, spleen, pancreas, and adrenal, have been advocated and used, for the most part empirically. Thyroid extract, iodin, and iodothyroglobulin have effected benefit in some cases; also antithyroid serum and other thyroid preparations. The serum of thyroidectomized sheep and dried milk of thyroidectomized goats have been used. Radium and the X-ray are also employed to some extent.

Contra-indications to Operation.—While some surgeons recommend that operation be proposed to practically all patients, the majority consider that there are definite contra-indications; these are:

1. Profound secondary changes in other organs, especially the heart and kidneys. Marked dilatation of the heart, extreme rapidity and irregularity of the heart action and evidences of severe nephritis, if not improved by treatment, contra-indicate operation. Operation should be delayed, as Mayo emphasizes, until the subsidence of gastric crises, acute delirium, diarrhea, ascites, and edema of the hands and feet.

2. Evidences of incipient myxedema. This, of course, precludes further diminution of the thyroid secretion by operation.

3. Status thymicolymphaticus. A persistent thymus has been particularly emphasized as a contra-indication by many authorities. On the basis of 60 autopsies, Capelle and Bayer state that in patients who had exophthalmic goiter but died as a result of other diseases, a persistent thymus was found in 44 per cent.; in patients who died as a direct result of exophthalmic goiter, a persistent thymus was found in 82 per cent.; in patients who died at the time of or soon after operation a persistent thymus was found in 95 per cent. Similar findings have been reported by others. The figures are sufficiently striking to cause thymic persistence to weigh heavily against operations on the thyroid,

but this factor cannot receive general application until the symptoms of persistent thymus are better understood and its recognition simplified, for, although percussion and X-ray findings are at times conclusive, they cannot be depended upon for diagnosis. On the other hand, it is a well-known fact that the coexistence of a persistent thymus with other evidences of status lymphaticus is frequently an important factor in the fatal outcome of operations. Therefore, in the presence of this condition operation cannot be recommended with safety (Mayo and McGrath).

OPERATIVE PROCEDURES

The operative procedures which are in general use are:

1. Ligation of vessels.
2. Partial thyroidectomy.

Method which may be regarded as being in the experimental stage:

1. Thymectomy.

Methods which have a limited applicability:

1. Sympathetectomy.
2. Injection into the substance of the gland.

Ligation of Vessels.—Vascular ligature for exophthalmic goiter was advocated by Wölfler as a means of diminishing the secretion of and absorption from the gland. As the result of ligation alone, the symptoms are often very favorably affected and the general condition improved; in some cases complete cure results (Mayo). But as a curative measure the procedure is less reliable and less effective than partial thyroidectomy. Its indications are:

1. Early cases with slight toxemia in which modification of the blood supply of the gland may reëstablish its normal equilibrium.

2. Severe cases in which temporary improvement may be obtained and enable a more radical operation to be supported.

3. To supplement extirpation of one lobe with ligation of the superior vessels of the other.

The question naturally arises as to how many vessels should be tied and in how many operations. As would be expected, the greatest effect is obtained by ligation of all 4 arteries. In 1895 Ridygier reported 22 cases of ligation of the 4 arteries with 20 cures or improvements and 2 failures, but no myxedema, tetany, or other serious complication. Kocher, in the same year, recommended successive ligations, fearing the occurrence of myxedema. He made a rule never to tie more than 3 arteries. He published 34 cases with 31 cures or improvements and 3 deaths. This conservative tendency still prevails and 2 or 3 groups of vessels are usually considered the proper number to ligate, although some operators ligate all 4 in successive stages. This has been done repeatedly without untoward results. The fact that the thyroid arteries anastomose with other arteries makes it extremely unlikely that insufficiency of the thyroid will ensue. However, when the 4 ligations are performed, a considerable interval should elapse between the third and fourth ligations so as to provide the thyroid and the parathyroids with sufficient blood supply through anastomotic channels, otherwise the procedure must be regarded as exposing the patient to an undue element of risk.

Technical difficulties are not great since the thyroid is rarely so large as to interfere materially with the isolation of the vessels. Experience indicates that the best results are obtained by mass ligation in the case of the superior thyroid so as to include the vein or veins, lymphatics and nerves together with the artery. Bérard suggests that the metabolism of the gland is affected through tying the nerves which accompany the vessels. The superior vessels are elected as a rule, in preference to the inferior, because they are more accessible and sufficiently large to produce a marked effect upon the gland; moreover, the operation does not involve the danger of interfering with the blood supply of the parathyroids or injuring the recurrent laryngeal nerve.

Partial Thyroidectomy.—Partial thyroidectomy is undoubtedly the most efficient treatment, operative or otherwise. But the observance of many details and the use of extremely good judgment are essential for its safe employment. Attention should be drawn to the fact that there is a growing tendency to reserve partial thyroidectomy for the final step in a "graduated" attack upon the thyroid, with vascular ligations as preliminary steps. As an initial procedure thyroidectomy is unnecessarily radical for some cases and too dangerous for others; in selected cases, however, it may be applied at the outset. The amount to remove is the important feature. Ideally, a delicate balance should be established so that the patient has enough thyroid to supply physiological requirements and yet not enough to allow the continuance of a pathological surplus. While from 1/6 to 1/4 of the gland, that is, about 1/2 of a lobe, is said to be sufficient to supply the necessities of the body, provided the part left is capable of functionating in a normal manner, it is the limit of safety. Riedel and others counsel extensive resection up to this point, arguing that the chances of cure are in direct proportion to the amount of gland removed. Whereas, in general, this is true and removal of about 3/4 of the gland—that is, 1 lobe and 1/2 of the other lobe—will give a greater guarantee of complete and rapid cure of the hyperthyroidism than the removal of a smaller portion, this arithmetical rule is not absolute. Moreover, in attempting to approach the limit of safety too closely there is danger, although slight, of overstepping it, with resulting myxedema; and, further, resection of the second lobe increases the danger of troublesome hemorrhage and of acute toxemia. Therefore, the disadvantages of removing too much and the possibility of resorting to subsequent resection, if insufficient tissue has been removed at the first operation, very definitely indicate a conservative policy.

There is little reason why resection of the second lobe should not be regarded as a step in the "graduated" operative treatment of the disease. It should be understood before operative procedures are begun that they may involve more than one operation upon the gland. This attitude would lead the surgeon to limit the thyroidectomy to a relatively safe procedure and would not cause a reflection upon surgery by the failure of the symptoms to disappear after the first operation.

The general and safe rule prevails of leaving the smaller lobe intact and of removing the larger or more vascular lobe together with the isthmus. If this procedure proves inadequate resection may be performed subsequently; this is an infinitely better policy than radical efforts at the first operation upon the gland to approach too closely the physiological equilibrium of the gland and the limit of safety of the patient.

The conservative practice outlined above is not to be considered an absolute rule. In certain selected cases of large bilateral goiter, excision of one lobe and resection of the other is justifiable at one operation. It has also been recommended that in these cases the functional activity of the second lobe may be diminished by ligation of its superior vessels rather than by resection.

The operative conditions differ from those which prevail in ordinary goiter; on the one hand, the gland ordinarily is not greatly enlarged, is not deeply situated, does not present awkward processes or projections, and is not adherent to adjacent structures. These factors would tend to simplify the operation, but they are, as a rule, more than offset by the size and friability of the veins, the adherence of the outer capsule and the friable and vascular nature of the thyroid tissue. In view of these features, the operation is much more dangerous and difficult than one for simple goiter. But the real danger consists in acute and at times fatal disturbances which may occur soon after the operation. The technic of the operation is the same as for extirpation for simple goiter; the only features to emphasize as particularly important in connection with exophthalmic goiter are the necessity for absolute hemostasis and extreme care and gentleness in the manipulations. Observance of these precautions favors a smooth postoperative course. Details of the technic of the operation will be described later.

Thymectomy.—Extirpation of the thymus has been recommended for the treatment of exophthalmic goiter, but too little is known of the indications for and results of the procedure for judgment to be passed upon it at the present time. Garré, 1910, removed the thymus in a case of Basedow's disease without interfering with the thyroid. No change resulted in the goiter, but a distinct improvement was noted in the general condition of the patient. Especially striking was the calming of the heart and the change in the condition of the blood; the lymphocytes dropped from about 40 per cent. to 22 per cent. Sauerbruch also removed the thymus in a case of Basedow's disease and found the blood picture to be more improved by this than by removal of part of the thyroid gland.

Many features point to the thymus as a factor which must be reckoned with in the consideration of the surgical treatment of exophthalmic goiter. We can touch upon them, however, only very briefly; full details may be obtained by consulting the authorities cited below.

An enlarged thymus has been held responsible for many of the sudden deaths which have occurred during or directly after operation for exophthalmic goiter. Death in these cases has been variously attributed to pressure of the thymus upon the great vessels and trachea, to status lymphaticus (status thymicolymphaticus), and to thymogen intoxication.

Autopsy findings show that in a large proportion of cases an enlarged thymus is associated with Basedow's disease. The statistics of Capelle and Bayer have already been cited; Matti, Melchior, Gebele, Bier, and others have made similar observations.

Experimental work upon the thymus has resulted in significant findings. For instance, Gebele implanted thymus gland in the abdominal wall of a young dog and 9 weeks later the thyroid and the parathyroids were removed. The animal remained well. In consequence he suggested that the thymus replaced the thyroid. Bircher produced symptoms suggesting acute Basedow's disease in 5 dogs by implantation of fresh hyperplastic thymus in the peritoneal cavity. Similar experiments with normal thymus gland produced no recognizable disturbance. (Klose, Mayo and McGrath, Capelle and Bayer, Parker, Zesas.)

Intervention on the Cervical Sympathetic.—Sympathetectomy was enthusiastically tried after its inauguration by Jaboulay in 1896. He practiced section of the nerve; Jonnesco recommended resection of the superior and middle ganglia with the intermediate nerve. The results were extremely variable and cures so exceptional that the method was practically abandoned. However, Mayo has recently advocated the operation for cases with extreme exophthalmos and marked nervous symptoms but with small thyroid. Sympathetectomy and ligation of the superior thyroid vessels are performed through one incision. He states that the operation not only improves the exophthalmos but produces great improvement in the general symptoms. (Jour. Am. Med. Assn., 1914, lxiii, 1147.)

Injection.—Injection into the gland of iodoform and ether and other substances was formerly practiced, but was discarded as a dangerous procedure. Porter has recently advocated the injection of boiling water, minims 100-400.

Summary of Operative Indications and Contra-indications.—A brief trial of non-operative treatment is indicated in the early stages of the disease. If improvement is not marked and lasting under such treatment operation is indicated. In acute exacerbations of the disease non-operative treatment should always be pursued until the subsidence of the acute symptoms, after which operation should be recommended. In advanced cases, before operation is undertaken, complications should be treated so as to render the condition of the patient as favorable as possible.

No one symptom should preclude operation; the general condition of the patient must be the criterion. In the absence of evidences of myxedema or status thymicolymphaticus, the dictum of Kocher may be adopted, that operation is contra-indicated only in cases which present degeneration of the heart muscle, with low blood pressure, irregular pulse and periodic attacks of delirium cordis, that is, extreme rapidity of the heart with very irregular pulse. Unless the heart is seriously affected, judicious preliminary treatment frequently brings about sufficient improvement to warrant operation.

Summary of Choice of Operative Procedures.—In early and mild cases the superior thyroid vessels of both sides are ligated at 1 operation. In severe cases the superior vessels are ligated in 2 stages, with an interval of 10 days or more between. In cases of moderate severity primary partial thyroidectomy with or without ligation of the superior vessels of the other lobe may be performed primarily.

Subsequent steps in all of the three varieties are determined by the course of the disease, condition of the patient, and the size and condition of the thyroid. In mild cases, if symptoms persist or recur after vascular ligation, the larger lobe should be excised or one of the inferior thyroid arteries may be ligated, reserving excision for a subsequent operation. In severe cases partial thyroidectomy is performed as soon as sufficient improvement has occurred after the first or second ligation to warrant the operative risk. In any of the varieties, if excision is followed by persistence or recurrence of the symptoms, resection of the second lobe or fourth ligation is indicated. The latter, however, is only performed when a sufficient time has elapsed to allow some collateral circulation to be established.

Partial thyroidectomy or excision, as used above, imply in general removal of one lobe and isthmus. In the unilateral type of lesion this should always be the rule. In the bilateral type a similar amount usually should be removed and resection of the second lobe reserved for a subsequent operation; but if both lobes are large and the condition of the patient is reasonably good, excision of one lobe and resection of the other is sometimes justifiable at a single operation.

ANESTHESIA

The question of anesthesia is of great importance in operations for exophthalmic goiter. The choice of method of anesthesia is largely dependent upon the condition of the patient and the attitude of the operator in regard to the relative advantages of local and general anesthesia.

In general, it may be said that for most vascular ligations, especially of the superior vessels, local anesthesia is appropriate, and for most partial thyroidectomies general anesthesia should be employed. But the question of anesthesia in these cases cannot be so easily dismissed; the principles involved must be elaborated. Basedow's disease is a manifestation of nerve excitation; the symptoms are aggravated by unrest, excitement, and anxiety; the postoperative course is markedly affected in proportion as these factors are present or absent before, during and after the operation. Ante-operative anxiety, the mental unrest and perhaps physical suffering which attend a moderately prolonged operation under local anesthesia, or the excitement associated with the sudden and crude administration of a general anesthetic, tend to aggravate the symptoms of the disease, at times to a serious degree, perhaps even to the extent of turning the balance against the patient. Crile in particular has emphasized these features, stating that one of the greatest factors in the surgical risk is psychic excitation. An effort should be made to minimize ante-operative anxiety, to eliminate operative unrest and suffering, and to curtail shock.

In general, to meet the indications a preliminary dose of morphin (grain ¼) and atropin (grain 1/120) should be given about ½ to 1 hour before operation and the administration of the anesthetic delayed until the sedative effect of the preliminary drug is marked. The anxiety of the patient is thus considerably reduced and the anesthetic is more quickly effective. The anesthetic of choice is nitrous oxid-ether sequence, although ether alone or nitrous oxid and oxygen have their advocates. It is essential that the anesthesia should be administered with extreme care and should be light, smooth, and as short as possible. While the above is appropriate for routine cases, it may be wisely modified in extremely bad risks by following Crile's method.

Crile attempts to meet all of the indications by *anoci-association,* the principle of which is "the exclusion of all harmful stimuli, making the brain and the personality of the patient unmodified and unimpaired through the operation." His aim is to minimize ante-operative anxiety by "stealing" the gland without the knowledge of the patient; to eliminate operative unrest and physical suffering by the use of a general anesthesia, and to prevent shock by blocking the tissues in order to prevent the transmission of nerve impulses. While the principles involved have much to commend them, the relative importance of the various steps can be determined only after long experience. Crile proceeds as follows:

After the patient has consented to the operation she is given each morning a hypodermic injection of sterile water followed by the inhalation of small quantities of nitrous oxid and oxygen under the pretext of medical inhalations. On the morning of the operation a hypodermic of morphin and scopolamin is substituted for sterile water and the inhalation is carried to the anesthetic stage. The anesthetized patient is then transferred from her bed to the operating room. All tissues are injected with 1-400 novocain before division. Previous to closing the wound quinin urea hydrochlorid is injected around the whole exposed field. The anesthetized patient is then returned to her bed, the room being in the same condition as before the operation.

Intratracheal insufflation presents some advantages. *Chloroform* should be avoided on account of its danger. *Rectal anesthesia* has been recommended for use in cases of exophthalmic goiter. Theoretically it offers the advantage that the anesthetic, consisting of 5 or 6 ounces of ether with 2 ounces of olive oil, may be introduced without the patient recognizing that an anesthetic is being administered. On the other hand, as Coburn points out, "the margin of safety between surgical anesthesia and respiratory paralysis is apparently considerably reduced in the oil-rectal method." My own experience with the method is limited, yet the prolonged effect of the anesthetic after some operations (non-goitrous) and marked dyspnea, cyanosis and incomplete anesthesia in a case of exophthalmic goiter make me feel that the method is not to be recommended.

Local Anesthesia.—That the results may be good from operations performed under local anesthesia is attested by the fact that many eminent surgeons, including Kocher, Rehn, Socin and Jaboulay, have employed it as a routine measure.

The disadvantages of local anesthesia, besides the important psychic influences already mentioned, are that there is less freedom of dissection, the field of operation is not so thoroughly exposed and the patient may be restless or resistant; in consequence the operation is usually longer and more difficult than one under general anesthesia and unexpected conditions or accidents are dealt with less readily and with less confidence.

The chief advantages of local over general anesthesia are that deleterious effects on the kidneys, heart and lungs are for the most part avoided, and injury to the recurrent nerve is less likely to occur on account of the possibility of phonation in the conscious patient.

INDICATIONS.—Local anesthesia should be employed in cases presenting marked cardiac, renal or pulmonary disturbances, also when there is evidence of pressure upon the trachea, and in certain cases, as in singers, to minimize the danger of interference with the function of the vocal cords.

TECHNIC OF LOCAL ANESTHESIA.—Morphin is administered about ½ hour before operation. Novocain ½ to 1 per cent. with adrenalin is usually employed. For partial thyroidectomy the skin and superficial tissues are anesthetized along the proposed line of incision, the muscles are injected where they are to be cut, and a complete blocking of the field about the gland, especially the regions of the upper poles, is made by copious injections. The general features of the technic of local anesthesia are detailed in the article on anesthesia.

POSTOPERATIVE CARE

The surgeon's obligation does not cease with the operation. In exophthalmic goiter the after-care is especially important. The patients are poor operative risks and danger persists for several days. Immediate care consists chiefly in rest in bed, quiet, fluids, and the relief of symptoms. The length of time in bed must vary considerably. There should be as little as possible in the environment to excite or disturb the patient. Fluids should be administered freely, water being given by rectum either continuously or by injections about every 5 hours; if the rectum is intolerant, hypodermoclysis should be substituted. Sedatives, such as bromids, are to be given symptomatically; for excessive excitability and restlessness, Mayo recommends morphin or scopolamin (gr. 1/200), repeated as indicated. Cardiac stimulants are often indicated, and an ice cap over the pericardium does much to quiet the heart action. Atropin in small repeated doses is indicated if sweating is considerable (Mayo). If discharge is free, the dressings should be changed frequently. Drains should be removed about the second or third day.

The patient should be under constant medical supervision and advice for a long period after the operation.

POSTOPERATIVE RESULTS

The mortality from the operative treatment of Graves' disease has been reduced progressively so that at present in the hands of experienced surgeons it is about 4 per cent. or less. It is striking in reviewing statistics to note the much lower death rate obtained by all operators as their experience has increased. This must be attributed in part to improved technic, but chiefly to an acquired ability to select the appropriate operation and the proper time to operate, to more thorough preparation of the patient, and to the separation of operative procedures into stages. In regard to the technic of the operation, as Ochsner states, we now have a comparatively safe surgical procedure, since it is possible to avoid for the most part the principal dangers which were prevalent in the past, namely, those due to anesthesia, hemorrhage, shock, sepsis, acute toxemia, cachexia strumipriva, tetany, and injury to the recurrent nerves.

A valuable report on the results of surgical treatment in exophthalmic goiter was presented before the French Surgical Congress, 1910, by Delore and Lenoement. They found that the mortality of surgical treatment averaged 4 per cent., as calculated for about 1,500 operations. Combining cases of great improvement and cures, there were 666 favorable cases, 44 per cent. Non-operative treatment yielded 20 to 25 per cent. cures, and 10 to 25 per cent. mortality.

Kocher, in 1910, reported 469 operations for exophthalmic goiter with 3.4 per cent. mortality; in the last 72 the mortality was only 1.3 per cent. C. H. Mayo, in 1908, reported 200 cases operated upon in 1905, 1906, and 1907, with a mortality of 5 per cent., and in 1912 he reported a series of 278 cases with no death.

As evidence of the striking improvement, it is of interest to note earlier statistics. Thus, in 1904, C. H. Mayo reported 40 partial thyroidectomies for exophthalmic goiters with 6 deaths, 15 per cent.; while Bérard, 1896, gave the immediate mortality in cases of partial thyroidectomy for exophthalmic goiter from the compiled statistics of several operators as 15 to 30 per cent.

The chief cause of operative death is status lymphaticus; the chief causes of postoperative death are pneumonia and acute toxemia. Acute toxemia is of uncertain etiology. It has been attributed to the entrance into the circulation of hypertoxic thyroid products in the course of the work upon the gland or subsequently from wound absorption (thyreotoxic theory), and also to hyperstimulation of the vasomotor and trophic nerves of the region (nervous theory). Though it usually follows complicated operations, it may occur even when operation has been restricted to simple procedures. The chief symptoms are extreme tachycardia, violent excitement and fever. This toxemia is said to be present to a mild degree in about two-thirds of the cases. In severe cases it may be fatal through heart failure within 2 days, but as a rule it subsides in 2 or 3 days.

Functional End Results.—Kocher is of the opinion that in Graves' disease operations on the thyroid, when properly performed, almost invariably lead to an improvement or cure, but he emphasizes the importance of early operation. In 1912 Kocher reported the definite end results in 320 operative cases of exophthalmic goiter, showing a complete cure in 150 of the patients; 148 still presented individual symptoms of the disease but were considerably improved. Only 22 cases showed an unsatisfactory outcome either because the operation could not be completed or because there was relapse or because secondary disturbances (glycosuria, albuminuria, hepatic symptoms, edema) failed to subside after the operation.

C. H. Mayo, on the basis of 200 operations in the years 1905, 1906, and 1907, reported 70 per cent. cured, 19 per cent. improved, 5.8 per cent. slightly improved, 5.2 per cent. unimproved. In 1912 he gave 75 per cent. as the estimated proportion of cures, that is, "restored to usefulness, resuming former occupations, and nearly free from all former symptoms." Some exophthalmos, occasional tachycardia, and relapses of nervousness appear to have persisted in some of these.

Kuttner (62), University of Breslau, reported (1911) that of all cases in the Clinic during 18 years who had received surgical treatment 86.2 per cent. of those living were cured or sufficiently improved to pursue their work; 13.8 per cent. were unimproved. Of those treated medically 35.7 per cent. were dead and none of the living were cured.

Concerning the permanent results of the operative treatment of exophthalmic goiter (partial thyroidectomy), Weispfenning (116), writing from the First Surgical Department of the Hamburg-Eppendorf General Hospital, service of Professor Kümmell, points out that the cases operated upon during 1889 to 1900 have been reëxamined twice, first in 1901; again in 1905. The reexamination of 1901 covered 20 cases, the operation in the longest standing case dating back 11 years, while the interval in the most recent case was 1¼ years. In 18 of the 20 cases the operation had been perfectly successful; the remaining 2 were 1 failure and 1 death. The 19 surviving cases were again reëxamined in 1905, nearly 5 years later, with the following results:

Cure, 14 cases; marked improvement, 2 cases; moderate improvement, 3 cases.

The 14 cures must be considered as permanent, since the operation in the last case operated upon dated back over 4 years. Five of these 19 cases were examined for the third time, Weispfenning also making a first reëxamination of 11 of 15 cases operated upon from 1900 to the beginning of 1910. The 16 reëxamined cases are divided by him into 4 groups according to results:

permanent cures, 4 cases; temporary cures, 3 cases; improvements, 2 cases; recurrences, 5 cases; goiter developing on the side not operated upon, 2 cases.

Concerning remote operative results, Klose's (1911) compiled statistical material of 298 cases from several large clinics shows:

191 = 64 per cent. (2 to 18 years) cures.
72 = 24 per cent. improvements.
7 = 3 per cent. not cured.
6 = 2 per cent. recurrence.
22 = 7 per cent. deaths.

In cases of ligation without thyroidectomy Mayo's results were as follows:

	Cases
Slight improvement	9
Great improvement	44
Very marked improvement	11
Absolutely well	4
Cases of questionable exophthalmic goiter, no improvement	9

Whereas in most uncomplicated cases of exophthalmic goiter improvement in the toxic symptoms, such as tachycardia, tremor, and restlessness, occurs soon after operation, at times manifesting itself within a few hours, but usually in a few days, in some cases considerable time elapses before the beneficial effect manifests itself.

The definition of "cure" as used in the above statistics appears susceptible to differences of opinion or of observation. It seems in general to indicate an ability to resume former occupations, but does not always include the absolute and permanent cessation of all symptoms. Some exophthalmos, occasional tachycardia and attacks of nervousness appear to persist after operation in many cases which are otherwise returned to comparative health.

At times hypertrophy of the remaining portion of gland takes place with return of symptoms necessitating renewed operation. That such operations may be curative has been proved by numerous cases. Secondary permanent changes in other organs may prevent a cure

Rogers emphasizes the fact that partial thyroidectomy is much more dangerous in youth than in later life. He also states that after an apparent operative cure, pregnancy is likely to bring about a return of the symptoms.

"Experience teaches that it is very exceptional for too much of the gland to be removed when there is a positive diagnosis of hyperthyreosis." (Kocher.) Although myxedema has been known to follow even limited resections, signs of thyroid insufficiency as a rule gradually subside, the remaining tissue of the gland apparently supporting functional requirements.

Changes in the blood picture result from diminution of the activity of the thyroid by operation (Kocher). With hyperthyroidism is associated leucopenia and an increase in the relative number of lymphocytes. As a result of operation there is a fall in the relative number of lymphocytes, also an increase in the total leukocyte count. Some authors maintain that the degree of approximation of the number of lymphocytes to normal is a valuable index of the curative effect of an operation.

On the basis of the low mortality, 4 per cent. or less, and the favorable functional results, estimated at 75 per cent. of cures or improvement so great as to allow the pursuit of former occupations, operative treatment for exophthalmic goiter is strongly indicated. The appreciation of the value of surgical treatment for the disease has markedly developed in recent years.

SIMPLE GOITER

Operative Indications.—The indications for operative intervention in simple goiter are as follows:

1. PRESSURE DISTURBANCES.—The most frequent and important of these is pressure upon the trachea causing *dyspnea.* Dyspnea may be of gradual development from the growth of a readily recognizable goiter or of a concealed goiter developing within the thorax; or it may develop suddenly as the result of hemorrhage. A number of cases have been reported of hemorrhage into cysts which demanded prompt surgical intervention (Ehler, Elsberg). Pressure on the esophagus at times causes *dysphagia,* but rarely of serious degree. Pressure upon the recurrent laryngeal nerve, usually unilateral, is not rare. It may cause *hoarseness* and *cough.* At times partial laryngeal paralysis gives no symptoms and for this reason a laryngoscopic examination should be made before operation, otherwise the paralysis may be recognized after the operation and attributed wrongly to operative injury to the nerve. Occasionally pressure on the great vessels or on the nerves of the brachial plexus gives rise to symptoms which demand relief. Pressure on the vessels which drain the head, neck, and upper extremity may cause *cyanosis* and *edema;* pressure upon the brachial plexus may cause *neuralgic pains* in the upper extremity.

2. SUSPICION OF MALIGNANCY.—This is suggested by sudden development or rapid increase in the size of a goiter, especially if this is associated with sensitiveness and pain, and if the patient is of advanced years. It is essential that malignant goiters be operated upon early; therefore, suspicion of malignancy indicates immediate operation.

3. DEFORMITY OR DISCOMFORT.—While the mere presence of a goiter does not in itself demand operation, the disfigurement, discomfort, and possibility of untoward developments in most cases render operation advisable even in the case of small adenomata and cysts.

4. ABNORMALLY SITUATED GOITERS.—*Intrathoracic goiters,* although usually not recognized until pressure symptoms occur, should be attacked as

early as possible. *Lingual goiters* call for interference only if they cause symptoms.

5. SYMPTOMS OF TOXEMIA.—"There may occur with any simple goiter but especially with single or multiple adenomata, a slow chronic toxic condition which acts on the system somewhat like the acute toxemia of exophthalmic goiter, causing dilatation of the heart, nephritis, and general anasarca. Nervousness, tremor, and tachycardia may be present. Protrusion of the eyes does not occur in these cases, but the myocardial change may cause a widening of the palpebral fissure. These cases, often called Graves' disease, should be classed as complicated goiter." "The average lapse of time between the appearance of the goiter and the thyrotoxic symptoms is 14½ years." (Mayo and Plummer.) Kocher attributes some of these cases to prolonged use of iodin.

MEDICAL VS. OPERATIVE TREATMENT.—Although unnecessary delay has not the serious disadvantages in simple goiter as in exophthalmic, the belief is unwarranted that every goiter should first be treated medically. Upon most simple goiters medical treatment appears to have little effect; however, in diffuse goiters of adolescence iodin is often efficacious and several periods of iodin medication should be enforced before operation is recommended (Kocher), but the drug should be administered only in small doses and for short periods.

Contra-indications to Operation.—If the patient is a poor subject for operation by reason of circulatory, respiratory, renal or other disturbances the indications for operation must be carefully balanced against its risks. An existing goiter is at times the apparent rather than the real cause of serious toxic or pressure symptoms. This fact should be borne in mind and it should be established that the thyroid is the cause of the symptoms before operation is undertaken.

SURGICAL PROCEDURES

A number of surgical procedures for the treatment of simple goiter are at the disposal of the operator whose choice must depend upon the individual indications of the case.

The procedures in general use are:

1. Excision (extirpation, hemi-thyroidectomy) (Kocher). Removal of one lobe or one lobe and isthmus.
2. Resection (Mikulicz). Removal of part of one lobe or parts of both lobes.
3. Enucleation (Socin, Billroth). Separation of a discrete nodule or cyst from the thyroid tissue.

The above methods may be used in combination.

4. Exenteration (Kocher). Incision of tumor or nodule and evacuation of its contents.
5. Incision of cysts.

Procedures which have been employed occasionally as emergency measures include:

1. Dislocation of the goiter; endothyropexy and exothyropexy.
2. Isthmectomy.
3. Tracheotomy.

There are also numerous discarded methods.

The various procedures will be discussed in the order of the above enumeration.

Excision.—Excision or extirpation of one lobe is the safest procedure and is thoroughly satisfactory in appropriate cases. It is especially indicated in diffuse goiters, the larger lobe being excised, with or without resection of the other lobe. It may also be used in nodular goiters which present in one lobe multiple nodules which cannot be treated by enucleation. When the isthmus is diseased or is readily removable it is excised together with the lateral lobe. A pyramidal lobe is likewise usually removed.

Resection.—Resection is more dangerous than excision of a lobe, since the hemorrhage is greater and more difficult to control owing to the friability of thyroid tissue. Resection, however, offers the advantage of safeguarding the parathyroids and the recurrent nerve; it may be employed under the following conditions:

1. In diffuse goiter when unilateral excision has already been performed either at the same or at a previous operation. Under such conditions the posterior part of the remaining lobe must be left to insure a sufficiency of parathyroids, since it is always possible that 2 have been removed with the first lobe. Extirpation of the second lobe, leaving only the isthmus, is a bad procedure since it may reduce parathyroid tissue to a dangerous degree. A review of the reported cases of tetany shows that excision of both lateral lobes leaving the isthmus has been a relatively frequent cause of tetany.

2. In some large bilateral diffuse goiters bilateral resection may be employed advantageously to produce a symmetrical result.

3. The removal of the greater part of a lobe in a diffuse goiter by shelling out the tissue so as to leave the posterior part with a lip on each side is at times elected in preference to excision of the entire lobe. This is really a modification of resection; to classify it under enucleation, as is sometimes done, is confusing; the latter term should be confined to the removal of discrete nodules or cysts.

4. To remove a part of a gland which contains several discrete tumors that cannot be enucleated.

Enucleation.—Enucleation consists in the separation of a discrete, localized, encapsulated tumor from the thyroid tissue. It is employed for cysts and adenomata. The method should be elected when feasible even in the case of large adenomata or cysts. It may be employed for several nodules; if the remaining tissue is markedly injured as a result of the enucleations, excision or resection of the lobe may be substituted. If one lobe has been removed or is atrophic, enucleation should be used, if possible, instead of resection, in order to conserve as much as possible of the remaining lobe.

Combined Methods.—Combined methods, that is, enucleation and resection, enucleation and excision, resection and excision, are frequently employed. Thus, in large diffuse colloid goiters, excision of one lobe and resection of the other is often advantageous.

Incision of Cysts and Exenteration.—Exenteration, which means literally evisceration, consists in incision of a nodule and intracapsular removal of its tissue, usually piecemeal.

Incision of cysts and exenteration are effective procedures for the relief of pressure, particularly when there is danger of asphyxia and prompt relief is imperative. These procedures are especially applicable to intrathoracic goiters because the confined position of the mass often renders complete extracapsular removal impossible. Intrathoracic nodules and cysts are likely to be associated with the development of dyspnea to a serious degree, and by reason of their concealed position, dyspnea is in some cases the only evidence of their presence.

In conditions other than intrathoracic goiters, exenteration and incision of cysts are only indicated when immediate relief of pressure is imperative and removal of the mass is impossible by reason of the condition of the patient or conditions of the growth, such as firm adhesions.

Displacement or Dislocation.—Operative displacement or dislocation of a goiter consists in freeing and dislocating the goiter so that it lies either external to the skin wound, *exothyropexy,* or beneath the skin wound, *endothyropexy.*

Exothyropexy has been rejected unconditionally by Kochner and Lanz and only admitted as a last resort by v. Eiselsberg and others for the rapid liberation of the trachea in asphyxia due to the goiter.

Endothyropexy has been used both as an accompaniment of enucleation, resection or excision and as an independent operation of choice, particularly in small recurrent goiters and small goiters of cretins. Its rare indication is the relief of pressure from a goiter when hypothyroidism would be likely to result from removal of thyroid tissue.

Isthmectomy.—Isthmectomy has been recommended and occasionally performed for the relief of pressure upon the trachea. While it has been effective in some cases, the result will usually be disappointing because the pressure is not as a rule dependent upon the binding together of the lobes by the isthmus, but rather, as Mayo points out, to the fascial envelope (surgical capsule) around the lateral lobes which occasionally offers more resistance to the developing goiter than does the trachea. Yet the procedure may be employed with little loss of time in the course of an operation for the relief of pressure and may prove effective.

Tracheotomy.—Tracheotomy is rarely indicated. It should be reserved for cases of profound dyspnea in which other methods of relief are not feasible or safe. If the isthmus is large or low, tracheotomy may prove an extremely difficult and dangerous procedure. In a case in which I assisted the late Dr. W. T. Bull, a tracheotomy was performed for extreme dyspnea caused by compression of the trachea by the left lobe of the thyroid. The condition of the patient was

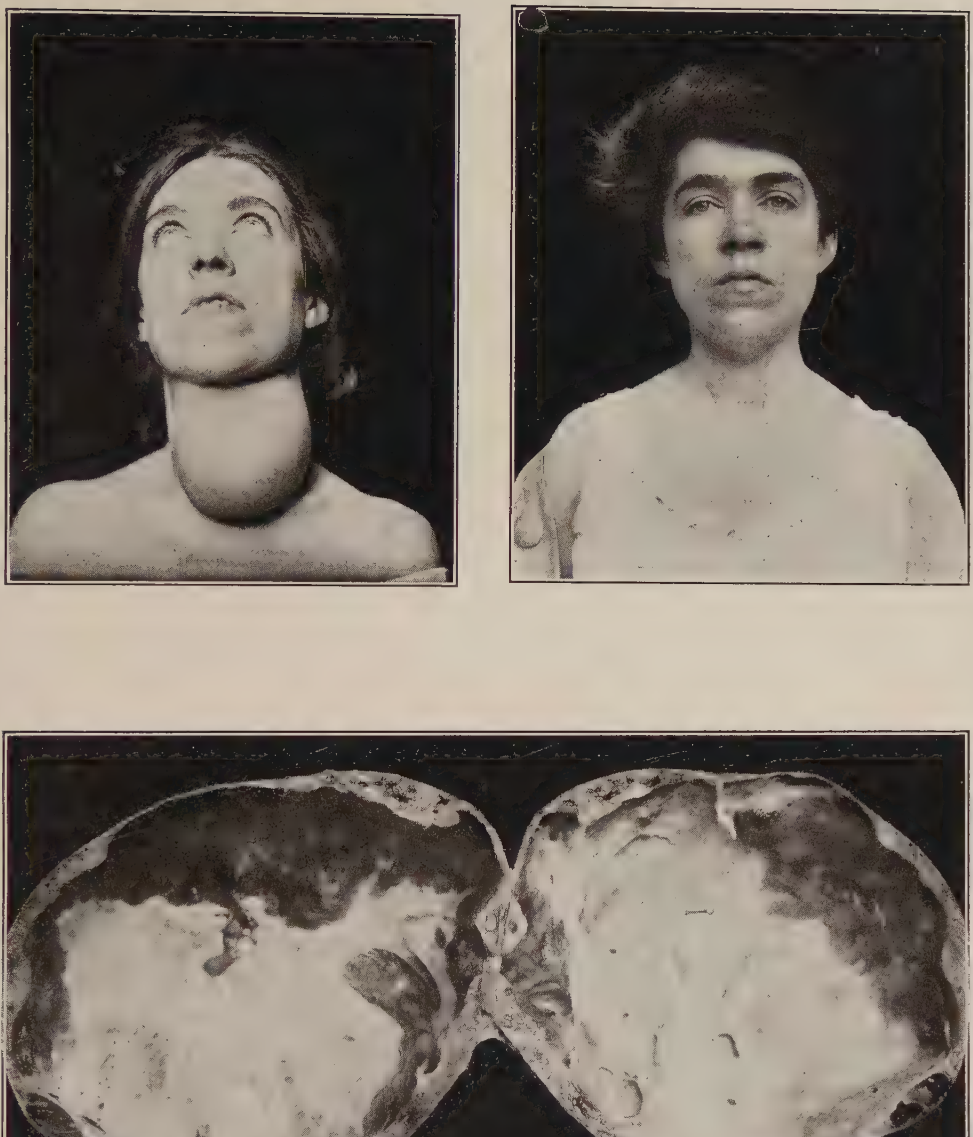


Fig. 5.—Cystic Goiter Before and After Operation. Cross-section of Cyst.

such that no other procedure seemed warranted. A low tracheotomy was performed and a metal tube was inserted. The patient died as a result of secondary hemorrhage. At autopsy it was found that the tube had caused erosion of the wall of a large vein in the upper part of the mediastinum.

Choice of Procedure for the Relief of Dyspnea.—For the relief of dyspnea, the choice between the operative methods already given must depend upon the size, situation, and character of the goiter, the facilities for operation and the urgency of the symptoms. If conditions warrant a radical operation, the appropriate method should be employed, namely, excision of lobe, resection or enucleation, otherwise a palliative procedure is indicated. Of these, incision of cysts, exenteration, isthmectomy and tracheotomy should be considered and applied as indicated. It should be remembered, moreover, that the incision of cysts and exenteration are as effective and frequently produce as permanent results as more radical procedures.

Obsolete Procedures.—Numerous methods belonging especially to pre-aseptic days have been used for the treatment of goiter, but have been for the most part abandoned and are now of little more than historic interest. Of these may be mentioned cauterization, subcutaneous crushing, drainage with setons, acupuncture, galvanopuncture, interstitial punctures and injections with a great variety of substances, but especially with preparations containing iodin or iodoform which were believed to have a specific effect on the gland substance. The injection method not infrequently gave rise to infection, and a fatal outcome was not unusual. Twelve deaths in consequence of injections were collected by Heymann in 1899, and this number was doubled in 2 years in the list of deaths published by Wölfler.

RESULTS OF OPERATIONS FOR SIMPLE GOITER

Mortality.—The mortality of operations for simple goiter is extremely low and may be estimated conservatively as less than 1 per cent. in the hands of skillful surgeons. Kocher, 1912, reported 603 uncomplicated goiters without death, and 19 recurrent goiters with no death. Palla and Schloffer reported in 1909 and 1910 from the Innsbruck Surgical Clinic 484 operations for nonmalignant goiter, with 6 deaths, 4 due to pneumonia, 1 to epilepsy, 1 to heart failure possibly due to an enlarged thymus. It is unnecessary to quote further statistics; analyses of the reports of all large clinics indicate a similar insignificant mortality rate.

Postoperative Complications.—The postoperative complications may be avoided to a large extent by the exercise of care in technic and by pre-operative treatment to improve the condition of patients who are poor operative risks. Pneumonia and other complications of operations in general are at times unavoidable. Hemorrhage, serious infection and severe shock should rarely, if ever, occur. Tetany and myxedema are extremely rare complications; they will be discussed later. The esophagus and trachea have been opened in rare cases;

such an accident may lead to infection. An esophageal wound, if sutured immediately, is said to unite readily.

Dyspnea, however severe, if due to pressure by the tumor, is, as a rule, almost immediately relieved. If dyspnea persists, it is probable that the cause of the pressure has been overlooked and that a deep-lying focus, usually retrotracheal or intrathoracic, has been left. Prolonged pressure on the trachea may lead to absorption of its rings with consequent softening of its wall. As a rule, after the compression has been relieved, the normal caliber of the trachea ultimately becomes reëstablished, but the narrowing of the trachea sometimes persists for a considerable time. Occasionally the softened tracheal wall collapses during the operation and must be lifted and supported, or, if this fails, a tracheotomy must be performed.

Dysphagia usually persists for a time or even becomes aggravated during the first week, after which it gradually subsides. Symptoms due to pressure on vessels, such as *cyanosis* of the face and *edema* of the upper extremity, disappear as soon as the pressure is relieved.

Pressure on Nerves. (1) As a result of pressure by the goiter, a recurrent nerve may be profoundly affected. Nevertheless, even total unilateral paralysis has been cured by operation. Yet the muscles occasionally do not resume their function if the nerve has been involved for a considerable time. (2) As a result of the operation, according to Palla and Schloffer, changes of the vocal cords are much more common than is generally supposed, but the symptoms almost invariably subside or disappear. The injury, as a rule, is confined to 1 nerve and is rarely followed by permanent impairment of the voice; fortunately, complete paralysis of one cord may be compensated for to a great extent by increased action of the other.

Bérard notes 2 cases in which the ablation of the goiter relieved neuralgic disturbances of the upper extremity with incipient atrophy of the muscles of the shoulder.

TECHNIC OF OPERATIONS FOR EXOPHTHALMIC GOITER AND SIMPLE GOITER

The *operative procedures* about to be described are those which are employed in the treatment of simple goiter and exophthalmic goiter. They are procedures which are indicated either for the relief of symptoms of a systemic nature referable to hyperactivity of the thyroid, or for the relief of local disturbances caused by the presence of an enlargement of the thyroid.

General Considerations.—General precautions, which apply to all thyroid operations, irrespective of the indications, include: avoidance of trauma to the recurrent laryngeal nerve, preservation of parathyroids to avoid tetany and preservation of sufficient thyroid to avoid myxedema.

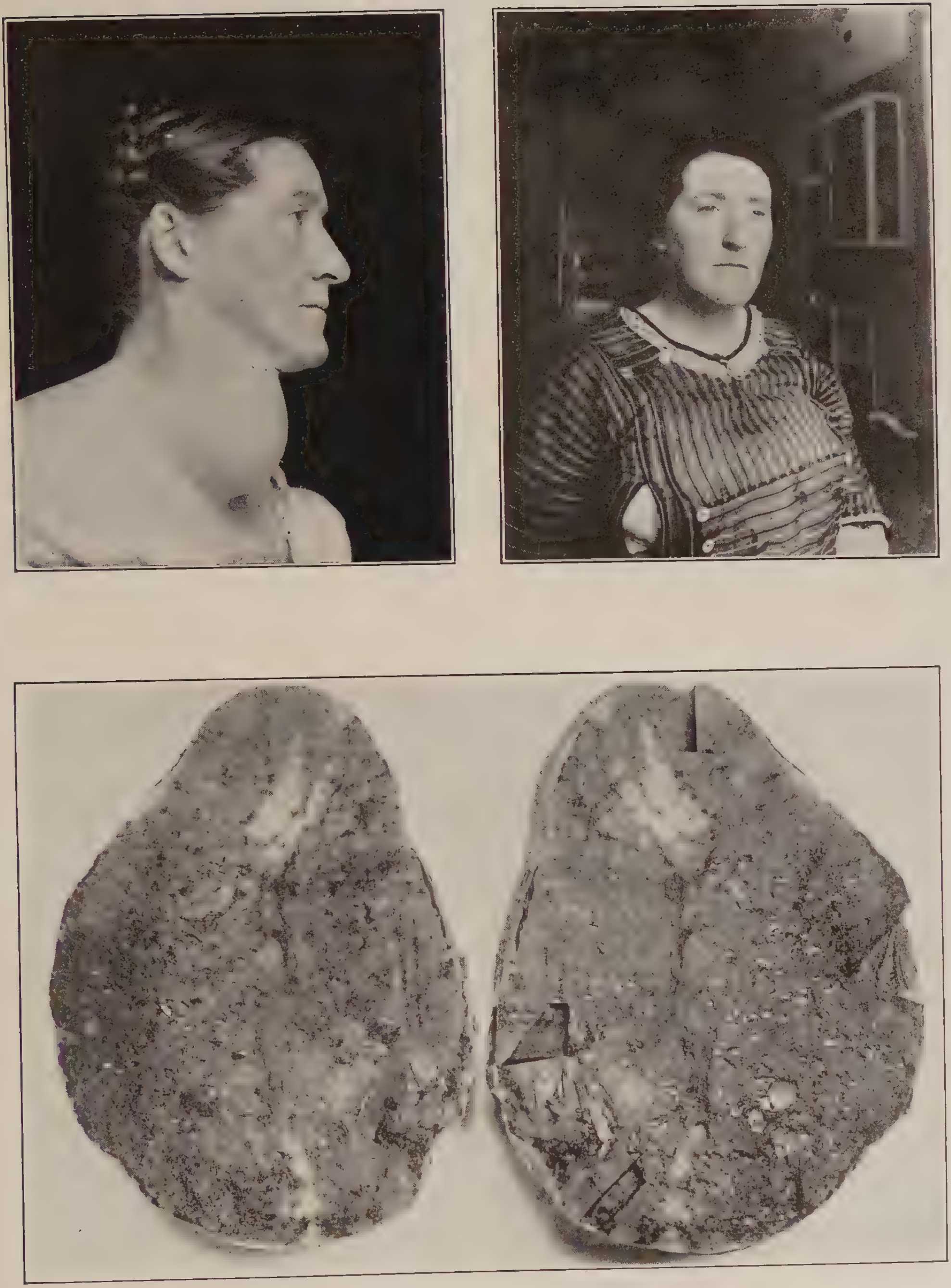


Fig. 6.—Adenoma of Thyroid Before and After Operation. Cross-section of Adenoma.

Specific precautions, which apply chiefly to operations for exophthalmic goiter, comprise: careful preparatory treatment until the symptoms are relatively quiescent so as to operate at a favorable time in the disease; proper selection of anesthetic; scrupulous watchfulness over the action of the heart and respiration during the anesthesia; diminution of shock by gentleness of manipulation, relative speed, adequate exposure, minimal loss of blood, and absolute hemostasis; curtailment of absorption by adequate drainage.

In any radical procedure upon the thyroid the essential technical feature is to provide a liberal exposure so that all steps of the operation may be performed in an open field. Only by the observance of this precaution can troublesome hemorrhage from the main thyroid vessels and from large thin-walled veins on the surface of the goiter be prevented or readily controlled.

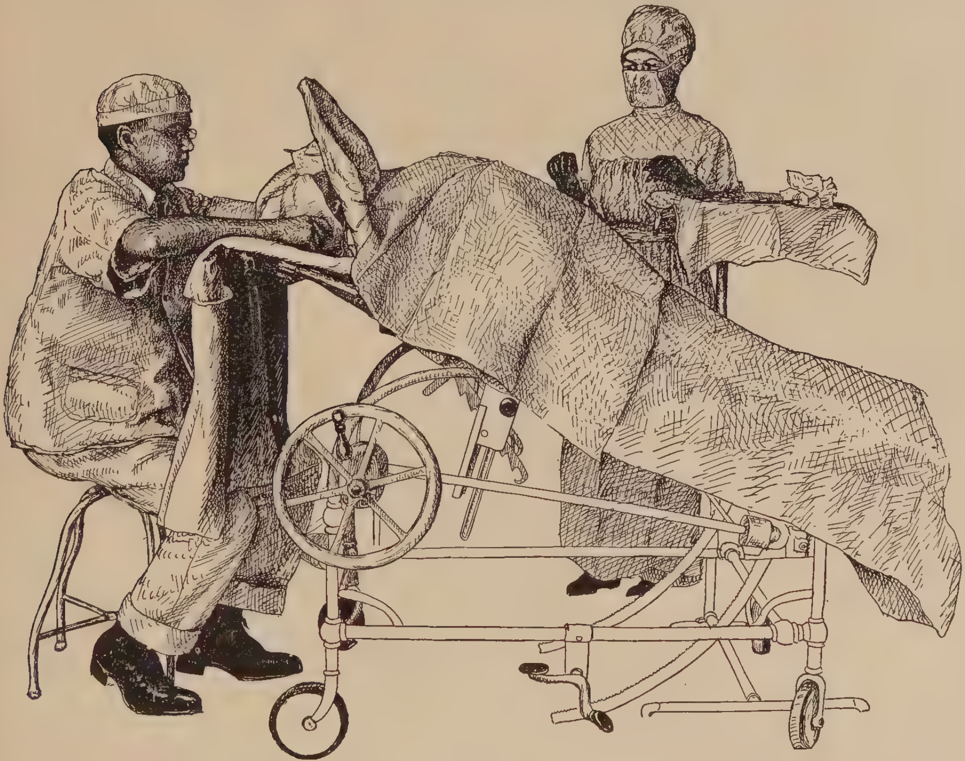


Fig. 7.—Patient Prepared for Operation, Showing Frame and Apron in Place, and the Oblique Position of the Patient.

A modern operating table should be used, adjusted so as to incline the patient downward from head to foot with the object of lessening congestion of the field of operation (Fig. 7). The shoulders are elevated on a sand bag and the head allowed to fall backward. This extends the neck and renders the operative field prominent. A wire hoop attachment is fixed to the table, passing across the lower part of the face at a distance of about 12 in.; to this is secured a sterile apron (Fig. 8), the lower edge of which is secured about the upper part of the neck. The patient's head and the anesthetist are thus excluded from the field. The remainder of the operative field is covered with sterile sheets and towels in the usual way.

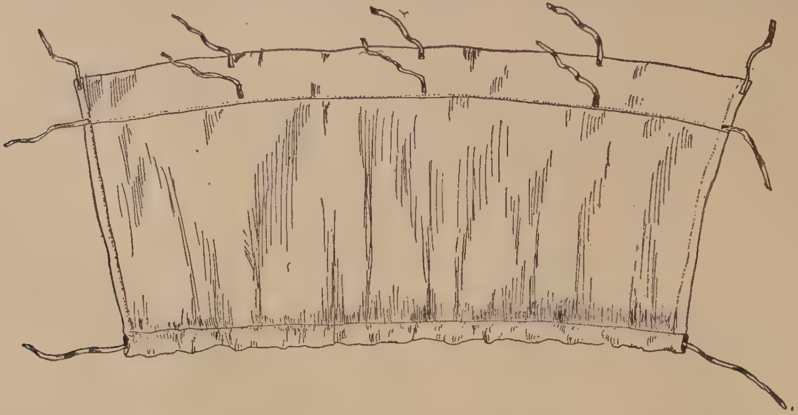


FIG. 8.—APRON WHICH IS ATTACHED TO WIRE FRAME AND AROUND THE NECK OF PATIENT. Forty-eight inches long, fourteen inches wide.

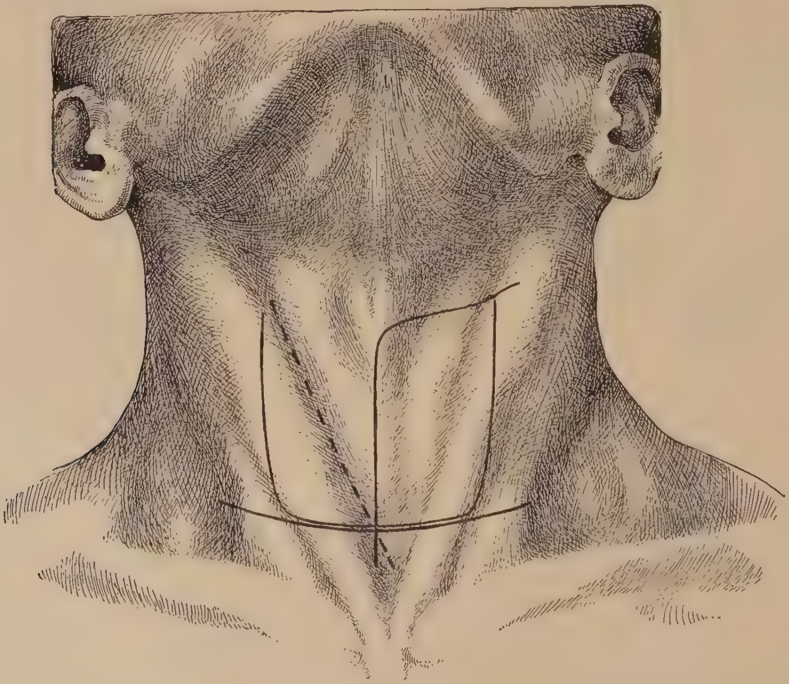


FIG. 9.—INCISIONS EMPLOYED FOR THE EXPOSURE OF THE THYROID GLAND.

Incisions.—Various incisions (Fig. 9) have been suggested and employed, of which the most notable are:

1. Transverse or "collar" incision.
2. U incision.
3. Hockey stick incision, which is formed by omitting from the U incision the upward prolongation on one side.
4. Oblique incision, which follows the anterior margin of the sternomastoid.
5. Angular or bayonet incision. This incision begins over the sternomastoid muscle at the level of the thyroid cartilage, passes inward and slightly downward to the mid line, thence vertically downward to the suprasternal notch.

The tendency at the present time is to use the collar incision when possible, modifying it, when necessary, by increasing its curve or extending 1 or both of its ends upward after the manner of the U or hockey stick incision.

EXCISION OR EXTIRPATION OF ONE LOBE OR ONE LOBE AND ISTHMUS

Incision.—The Kocher collar incision has distinct advantages over all others and should be used as routine. It is transverse with a slight curve, the concavity being upward, and should correspond as closely as possible to a natural fold or crease of the skin. The best cosmetic effect is obtained by a low incision about 3 cm. above the suprasternal notch or 2 cm. above the sternal end of the clavicle. But the position as well as the extent of the incision must be determined by the demands of the case, that is, the position and size of the part to be removed. The external jugular vein on one or both sides may be taken as the lateral limit of the average incision. It is justifiable to deviate from the typical transverse incision and to increase the curve or extend its ends upward, but variations should be reduced to the minimum which is consistent with proper exposure.

Operative Technic.—The skin and platysma are cut through and dissected together, upward and downward. Some operators cut the platysma on a slightly higher plane than the skin. The cervical fascia covering the muscles now lies exposed and in this fascia are the large anterior jugular veins (Fig. 10). Instead of making flaps of skin and platysma, as described, the original incision may be carried through the fascia down to the muscles, thus cutting the anterior jugular veins, which are clamped and ligated (Fig. 11). The separation of such a flap, including fascia and veins, is easy because of the natural cleavage plane between the muscles and fascia; at the anterior edge of the sternomastoid the layer of fascia that passes behind the muscle must be divided as the flap is lifted. Whichever method is elected, the upper flap should be freed, chiefly by blunt dissection, in general to the upper part of the thyroid cartilage; more or less as the case demands. It is held with a single sharp retractor placed near its base. The depressors of the hyoid now lie well exposed, in one case covered with fascia, in the other, free. They should be separated vertically with scissors passed between the sternohyoid muscles; if the relations of the parts are distorted, the natural division can be gauged by the situation of the incisura. Care is necessary to avoid injury to any underlying veins. The muscles may now be separated with retractors for slight work on the gland, such as enucleation of small nodules (Fig. 25). But, in general, for resection or extirpation, especially in large goiters and in Graves' disease, the sternohyoid, sternothyroid and omohyoid should be cut across and reflected on the side to be removed. In some cases I have found it advisable to cut the sternothyroid only (Fig. 11); this sometimes is sufficient because the sternohyoid and omohyoid have their insertions at a higher plane than the sternothyroid and are more easily retracted, especially in the region of the upper pole.

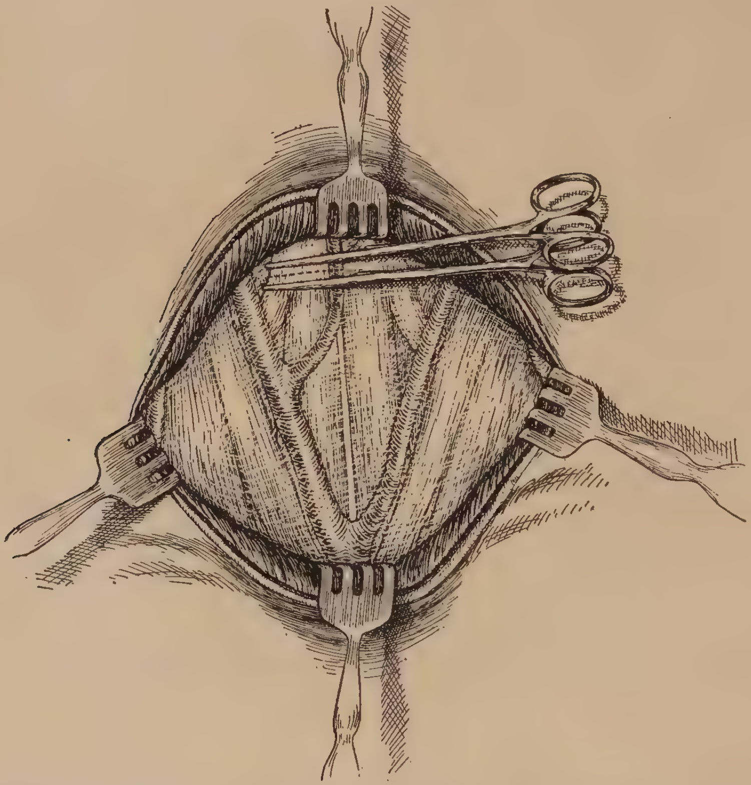


Fig. 10.—Original Incision Completed and Flaps Reflected, Exposing the Fascia Which Covers the Muscles and Contains the Anterior Jugular Veins. The flaps consist of skin and platysma (contrast the method used here with that employed in Figure 11). Clamps placed across upper part of sternohyoid, omohyoid and tributary of anterior jugular vein. The drawing does not show the separation of the muscles in the mid line which is necessary before the clamps are applied. The course of the anterior jugular veins was unusual in the part from which drawing was made. In this case the left anterior jugular would have to be ligated and cut at its junction with the right to allow separation of the muscles. External jugular veins show at lateral angles of the wound.

The line of division of the muscles should be high so as to avoid their nerve supply (Fig. 10). Two clamps of the Pean variety without teeth and with longitudinal serrations are used to grasp the muscles which are to be severed. They may be placed close together or at a distance of about 1½ cm. from one another, and should not be closed sufficiently to crush the tissue. The muscles are cut between the clamps, which are left attached to the cut edges. *This step may involve a confusing detail* in that the sternothyroid is frequently thinned and, since its mesial margin is not visible, the muscle may be left undivided when the sternohyoid and omohyoid have been cut, and the operator, believing he has severed all these muscles, may be confused by the appearance of thinned out muscle fibers overlying the capsule of the gland. With care, all the muscles may be severed together. Halsted, however, advises dividing the sternothyroid separately, after the others have been divided, because of the danger of injuring the veins of the capsule in passing a clamp blindly under all the muscles. It is unnecessary to follow a definite rule, but if the deeper muscle (sternothyroid) can be taken readily in the original clamp, it appears better to do so. The only important feature is to realize whether it is the capsule or the sternothyroid which lies exposed after the original division of the muscles.

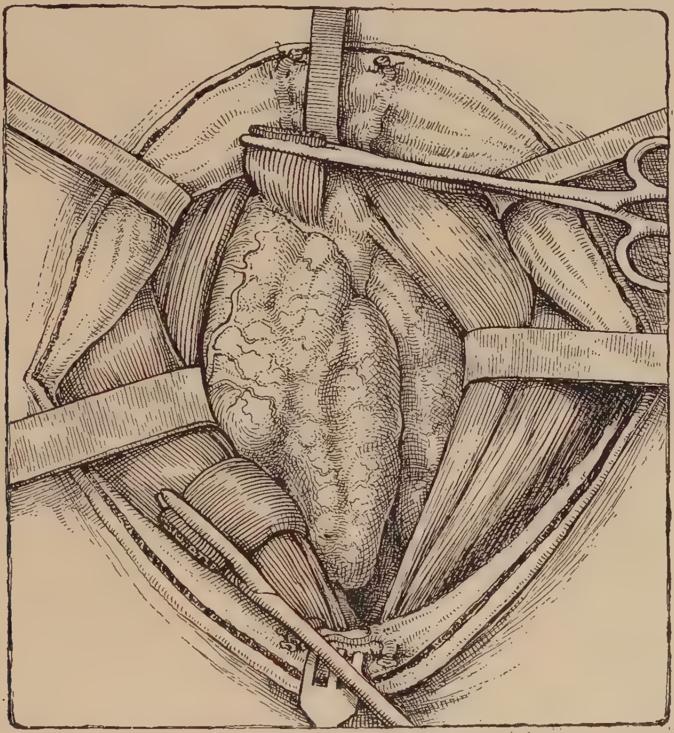


Fig. 11.—Enlarged Right Lobe Exposed. Right sternomastoid, sternohyoid and omohyoid retracted; sternothyroid cut and reflected. On left side muscles retracted. The original incision included skin, platysma and fascia which contain anterior jugular veins. The flaps contain these structures.

The handle of the lower clamp is slowly rotated and the muscles as a sheet are easily stripped free; the clamp is then allowed to hang over the outer edge of the wound; the sternothyroid, if divided separately, is treated in a similar manner. The lobe with the large veins of the capsule now presents well exposed. *Two important steps must now be taken,* namely, the ligation of the superior thyroid vessels and the incision of the surgical capsule to allow the "subcapsular"—that is, intracapsular—removal of the lobe. The order in which these steps should be carried out varies with the case. In small goiters the upper pole may be attacked at once. The pole is grasped with the fingers and lifted forward and the superior thyroid vessels ligated and cut. In large and vascular goiters, it is often well to incise the capsule before attacking the superior thyroid vessels. By way of preparation for the incision of the capsule, it is often advisable to liberate the lobe somewhat so as to expose its lateral surface. This is done by passing the finger gently into the plane mesial to the carotid and, keeping away from the capsule as much as possible so as not to tear the veins, freeing this tissue plane upward and downward. This liberates the lobe from the surrounding tissues to a considerable extent and if carefully done does not cause hemorrhage. The capsule is then opened vertically at the

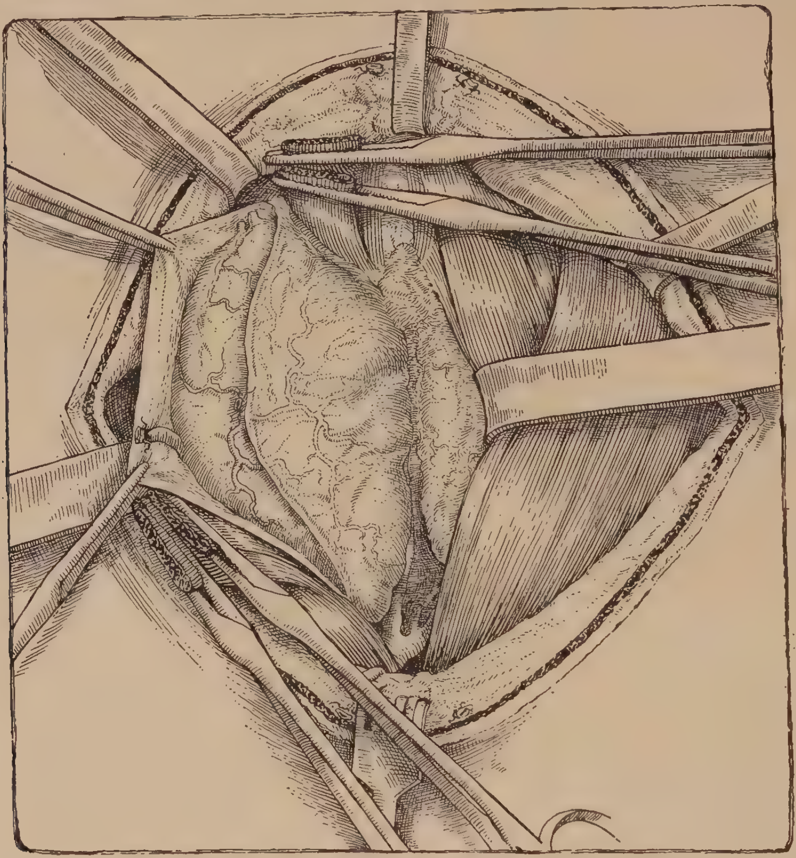


Fig. 12.—Right Lobe Exposed and Surgical Capsule Incised. Middle thyroid vein ligated. The original incision in this case included skin, platysma and deep fascia in which the anterior jugular veins lie. These veins are therefore cut, and reflected in the flaps. The sternohyoid and omohyoid were cut together between clamps; the sternothyroid was clamped and cut separately.

side of the lobe, far enough forward to allow control of hemorrhage should an accident occur (Fig. 12).

A Kocher enucleator is passed under veins that are encountered in the capsule and they are doubly ligated and cut between ligatures. Immediate double ligature is preferable to clamping with delayed ligation in such vessels and does not cause appreciable delay. The capsule is cut with blunt-pointed scissors downward as far as practical, then upward to the anterior aspect of the pole. The superior vessels are here encountered and should be exposed, a retractor being placed in the upper outer angle of the wound. The vessels should be thoroughly freed while gentle traction is exerted upon the gland and their ligation made with extreme care, a fairly long stump being left distal to the ligature. Secondary hemorrhage is said to be due most often to these vessels and has been ascribed to the inclusion in the ligature of muscle strands which subsequently may be drawn out of the ligature by movements of the neck. Whether

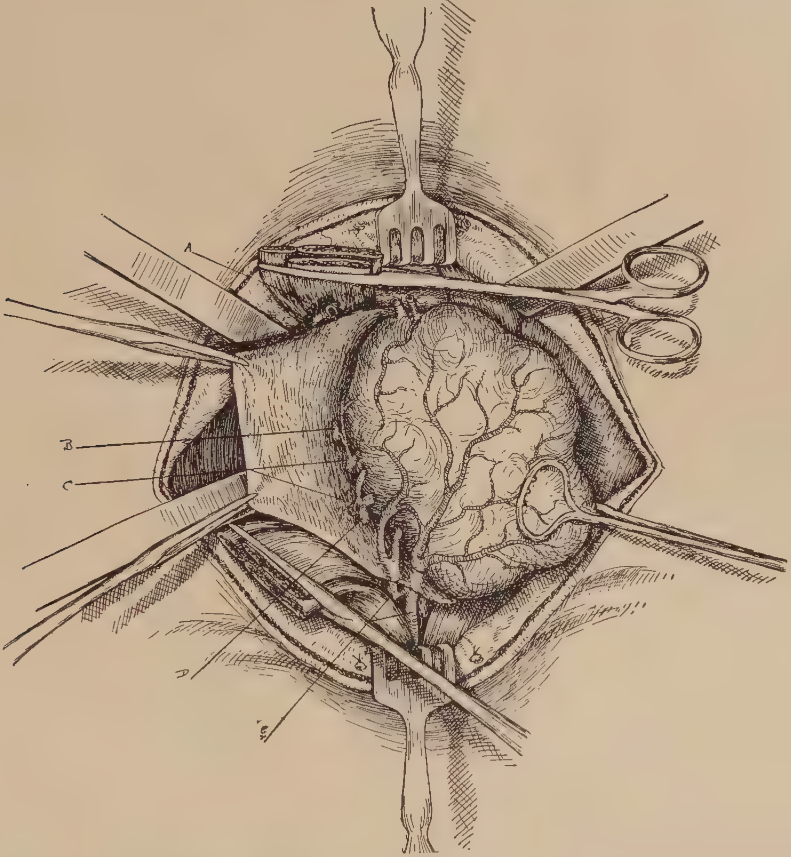


FIG. 13.—RIGHT LOBE FREED FROM THE SURGICAL CAPSULE. Superior thyroid vessels ligated and cut. Lobe drawn forward and well over to the left side exposing the inferior thyroid vessels and parathyroids. A, Stump of superior thyroid vessels; B, superior parathyroid; C, branches of inferior thyroid artery; D, inferior parathyroid; E, inferior thyroid veins.

the vessels are clamped or tied on the gland side is immaterial, although here, too, ligation appears advisable.

The upper pole is now dislocated and drawn forward and mesially by the assistant. The tissues are bluntly dissected or wiped off the posterior surface

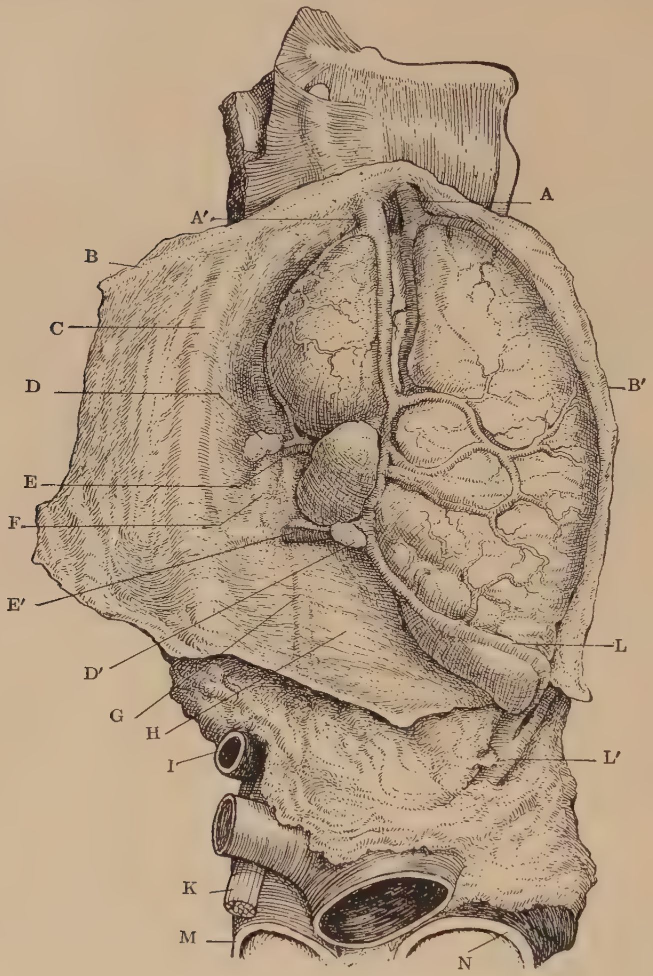


FIG. 14.—RELATIONS OF STRUCTURES POSTERIOR TO LATERAL LOBE. Thyroid viewed from side. Capsule cut and stripped from right lobe and the lobe drawn forward and to the left so as to expose the structures in relation with its posterior surface. The exposure has been carried out as in an operation with the exception that the superior vessels have not been severed. Drawing made from dissection of an autopsy specimen in a case of exophthalmic goiter. The relations of the parathyroids to the inferior thyroid artery and capsule are of particular interest in this specimen. The superior parathyroid stripped off readily with capsule, the inferior did not strip off and was left in close contact with the thyroid and the lower branch of the inferior thyroid artery. A, Superior thyroid artery after penetrating capsule, displaced somewhat anteriorly with the lobe; A′, superior thyroid vein; B and B′, surgical capsule stripped from the gland; C, common carotid artery beneath the capsule; D, superior parathyroid; D′, inferior parathyroid; E and E′, branches of inferior thyroid artery with accompanying veins; veins in this position are not usually noted; F, inferior thyroid artery beneath capsule before perforation of the capsule by its terminal branches; G, course of recurrent laryngeal nerve beneath capsule; H, situation of trachea; I, right subclavian artery; K, right vagus; L and L′, inferior thyroid veins; M, trachea; N, aorta.

of the lobe as it is lifted. This process is continued until the branches of the inferior thyroid artery are encountered (Fig. 13). These vessels are clamped and cut as they enter the gland. Small vessels need not be clamped on the gland side, because the continuous traction exercised by the assistant is usually sufficient to control hemorrhage. The dissection should be carried as close as possible to the true capsule of the gland and independent small bits of tissue should be sought for, stripped from the thyroid, and left uninjured. Halsted originally recommended clamping the branches of the inferior thyroid close to the gland substance rather than ligation of the vessel stem, because the blood supply of the parathyroids is better insured by this method. While this method is satisfactory, careful ligation of the main trunk is not contra-indicated. But, whether the main stem or its terminal branches are ligated, care should be taken to avoid including in a ligature or clamp the inferior parathyroid, which frequently lies in close relation to this vessel. If small bits of tissue suggestive of parathyroid are removed, they should be planted immediately beneath the capsule of the remaining part of the thyroid or into some other appropriate part

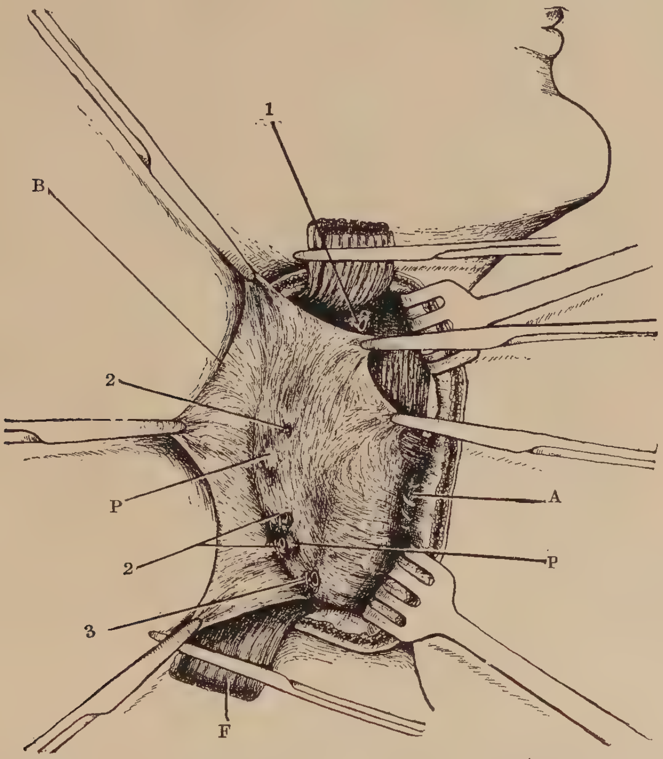


Fig. 15.—Lobe Removed. A, Isthmus cut across and cut surface sutured; B, surgical capsule; P, parathyroids; F, depressors of hyoid bone reflected. 1, Superior thyroid vessels; 2, branches of inferior thyroid artery; 3, inferior thyroid veins; drawing made at operation. The parathyroids and stumps of the branches of the inferior thyroid artery are external to their normal positions on account of traction upon surgical capsule.

of the wound. The lobe has now been freed without injury to the parathyroids or recurrent nerves which, as Halsted states, should practically never occur if this subcapsular procedure of C. H. Mayo is carefully carried out. Figures 14 and 15 illustrate the relations of structures posterior to the lateral lobe.

It is sometimes advisable, as suggested by Kocher, to modify this procedure by leaving a thin layer of the posterior part of the lobe in situ, the main portion of the lobe being resected. This method favors the preservation of the parathyroids and avoids injury to the recurrent laryngeal nerve. The procedure involves more troublesome hemorrhage, but in some cases, especially in diffuse simple goiters, it can be carried out readily. When the operation is performed for a recurrent goiter, one lobe already having been removed, it is imperative to leave the posterior part of the second lobe in relation with which 2 of the parathyroids usually lie.

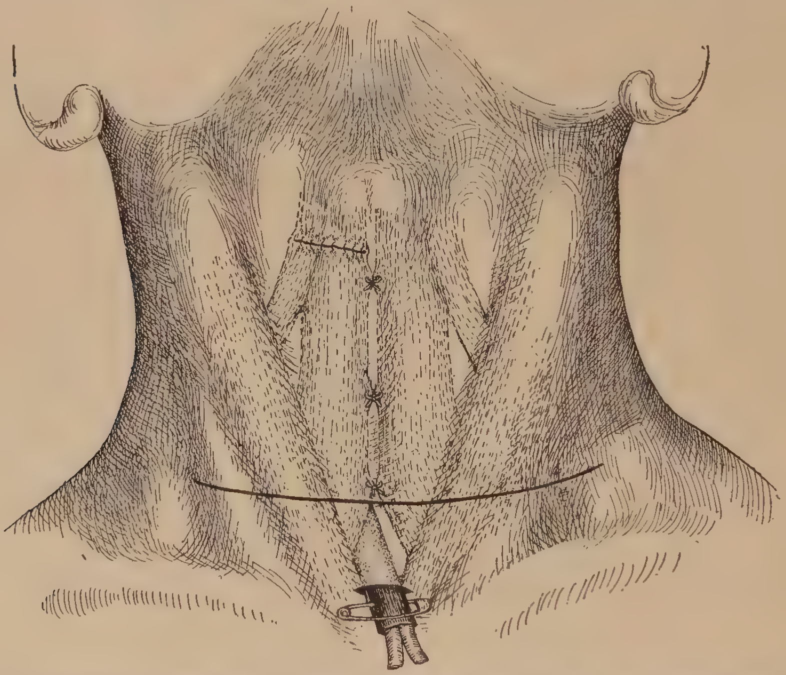
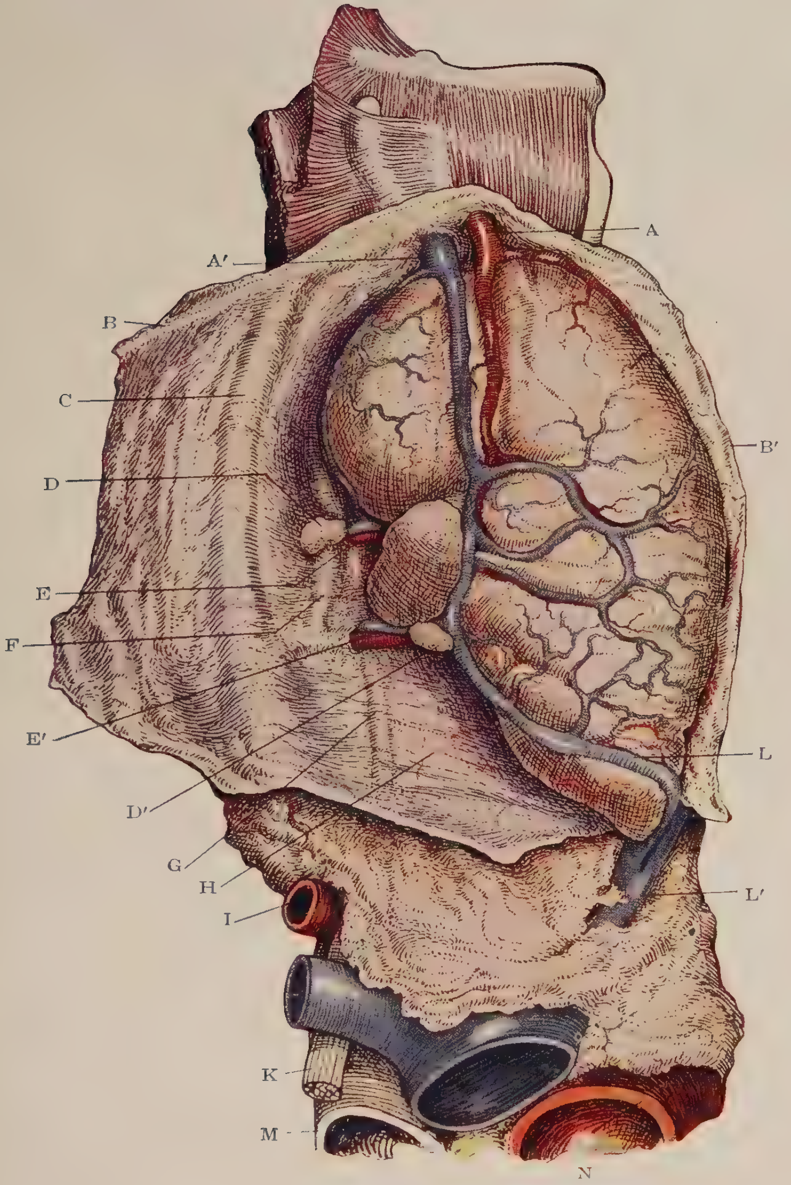


FIG. 16.—LAST STEP OF OPERATION. Muscles repaired; drain consisting of fenestrated rubber tube penetrated by two rubber tissue drains in place; skin incision closed by subcuticular stitch.

The isthmus should next be freed from the trachea as the lobe is drawn further to the opposite side. The isthmus may be crushed and ligated or clamped close to the other lobe and cut across. The clamp is then overhanded with a continuous stitch of catgut which is tightened after removal of the clamp. If a pyramidal lobe is present it should be removed; a strand-like remnant, representing the thyroglossal duct, should be cut. All hemorrhage should be completely stopped. In large bilateral goiters with symptoms of pressure on the trachea, Mayo counsels division of isthmus and dissection of the lobe out-



Relations of Structures Posterior to Lateral Lobe. Thyroid viewed from side. Capsule cut and stripped from right lobe and the lobe drawn forward and to the left so as to expose the structures in relation with its posterior surface. The exposure has been carried out as in an operation with the exception that the superior vessels have not been severed. Drawing made from dissection of an autopsy specimen in a case of exophthalmic goiter. The relations of the parathyroids to the inferior thyroid artery and capsule are of particular interest in this specimen. The superior parathyroid stripped off readily with capsule; the inferior did not strip off and was left in close contact with the thyroid and the lower branch of the inferior thyroid artery. A, Superior thyroid artery after penetrating capsule, displaced somewhat anteriorly with the lobe; A′, superior thyroid vein; B and B′, surgical capsule stripped from the gland; C, common carotid artery beneath the capsule; D, superior parathyroid; D′, inferior parathyroid; E and E′, branches of inferior thyroid artery with accompanying veins (veins in this position are not usually noted); F, inferior thyroid artery beneath capsule before perforation of the capsule by its terminal branches; G, course of recurrent laryngeal nerve beneath capsule; H, situation of trachea; I, right subclavian artery; K, right vagus; L and L′, inferior thyroid veins; M, trachea; N, aorta.

ward. In the rare event of collapse of the trachea owing to changes in its wall resulting from long pressure, it must be lifted with forceps or suture and, if possible, fixed by sutures to adjacent tissues or, if this is impracticable, a tracheotomy should be performed.

A counter opening for drainage is now made in the mid line below the incision. The object of this comparatively early preparation for drainage is to ensure recognition of hemorrhage from the puncture and its control before closure of the tissues is begun. The divided muscles are then united with fine chromic catgut. If the clamps have been placed some distance apart, so that considerable muscle edge has been left beyond them, the edges are sutured together and the clamps removed; but if they have been placed close together a different method is followed. In that case the clamps are approximated and a continuous stitch is taken around the two clamps. The clamps are removed and the stitch is tightened and tied. It is well to reinforce this continuous stitch with several mattress sutures inserted and tied before removal of the clamps. The drain is then inserted. The details of drainage are discussed below. A few interrupted plain catgut sutures are then placed so as to approximate the mesial edges of the sternohyoid muscles.

Closure of Wound.—Complete and careful closure of the platysma and deep fascia is essential to obtain a satisfactory scar. Interrupted suture is the most secure and consumes little more time than a continuous suture. The sutures are passed from the depth of the lower flap outward and then in the reverse direction through the platysma and fascia of the upper flap. When tied the knots lie under the fascia with no projecting ends. Mattress sutures are a disadvantage in that they cause puckering.

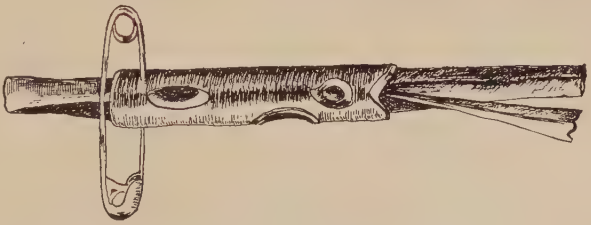


FIG. 17.—DRAIN USED BY THE AUTHOR. Fenestrated rubber tube penetrated by rubber tissue drain.

The skin is closed with subcuticular stitch of fine chromic gut with a small straight Hagedorn needle. Sterile adhesive plaster strips may be applied obliquely over the wound for greater security. A dry dressing is applied and covered with a starch bandage so as to prevent extension of the neck.

Drainage.—Drainage is indicated in proportion to the extent of cut surface of thyroid, the probability of hemorrhage, and the likelihood of toxic nature of the secretion. Thus, in enucleation of small cysts or adenomata, drainage often may be dispensed with, while resection of part of a lobe as a rule demands drainage. A counter opening for drainage is always preferable to drainage through the operative wound. First, it does not interfere with accurate approximation of the wound edges, and, second, superficial infection along the drainage tract is relatively innocuous in the punctured wound but is likely to extend along the operative wound and affect the cosmetic result by widening the scar.

The most serviceable form of drain for this and for similar operations, in my experience, is a fenestrated rubber tube through which is passed 1 or 2 rolled or twisted pieces of rubber tissue of a size which allows the rubber tissue to lie loosely in the caliber of the tube so as not to occlude it (Fig. 17). The rubber tissue should extend to the extreme depth of the wound, and the tube should project a short distance beneath the muscles. By this means early drainage is satisfactory, the rubber tissue does not plug, as does gauze, while its removal is easy, and when extracted it opens the caliber of the tube for further drainage. The rubber tissue should as a rule be removed in 24 to 48 hours, the rubber tube 24 to 48 hours later. If possible no drain should be reinserted.

RESECTION

Good exposure is absolutely essential for safety. The incision is planned according to the size and situation of the part to be removed. For small unilateral resections, a transverse incision is usually sufficient. For large bilateral resections a U incision may be necessary. The lobe or lobes are exposed just as for excision, with retraction or section of the depressor muscles as indicated. The part to be resected is freed by blunt dissection as far as this can be done safely without causing hemorrhage.

The following resections may be performed: Superior or inferior portions of lobe, isthmus, wedge-shaped vertical section from 1 or both lobes. Necessary vessels are secured prior to the removal of the tissue, but the thyroid arteries are not ligated as a routine preliminary or accompaniment of resection. Except in wedge-shaped resections, a heavy clamp is placed across the part to be removed and the tissue is cut away and a ligature or suture applied approximately in the same way as after section of the isthmus in excision.

Wedge-shaped resection is indicated in certain cases, although the procedure presents the disadvantage that the remaining tissue may be left in a damaged condition. In large diffuse bilateral simple goiters, bilateral resection gives the best results. The following procedure was used by me in the case illustrated in Figure 18, operated upon at the French Hospital in November, 1908.

The isthmus was clamped and cut across. The left lobe, the larger, was then freed considerably, leaving, however, the posterior part undisturbed. The largest veins were cut between double ligatures well back. Two large intestinal clamps covered with rubber tubing were placed one from above and the other from below, their ends overlapping slightly. (In a smaller lobe one clamp would be sufficient.) The clamps were closed sufficiently to control hemorrhage without crushing the tissue unnecessarily. Two parallel vertical incisions were then made and the main part anterior to the clamps excised. The cut surface consisted of lips forming a V on cut section. The edge was overhanded all around with a button-hole stitch, after which mattress sutures were passed at vari-

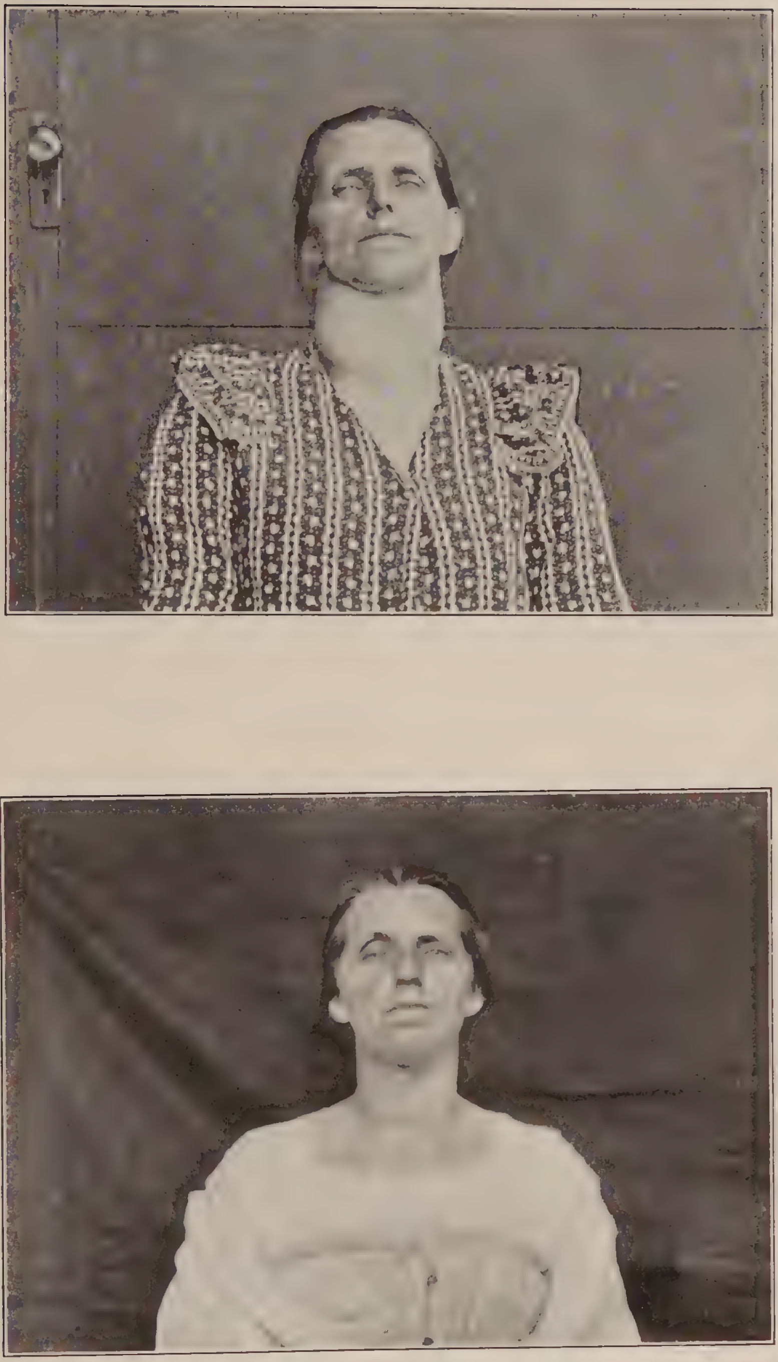


Fig. 18.—Diffuse Colloid Goiter Before and After Operation.

ous depths to bring the cut surfaces into apposition. There was slight general oozing and one vessel bled freely and was ligated. On the right side the superior thyroid vessels were ligated, after which the lobe was dealt with as on the other side. It was necessary to remove the cut stumps of the isthmus independently on each side.

This case demonstrates the feasibility of cutting across a lobe at will and of leaving the posterior part of a lobe with blood supply inviolate, thus ensuring the parathyroids and their blood supply and not endangering the recurrent nerve.

The advantages of double resection in certain types of goiter have been admirably presented by Balfour (2) in a recent communication. He describes the method employed at the Mayo Clinic, which is as follows:

> After freeing both lobes and planning what portions of each should be removed, the isthmus is divided and freed on each side from the trachea. "A series of Ochsner forceps are applied somewhat as follows: One at the superior pole, as a rule about an inch from the upper extremity, one at the inferior pole, three or four laterally, placed on the larger vessels in the capsule and two or three on the tracheal side. These forceps appropriately placed serve the joint purpose of marking the limitations of the resection and of enabling one to control hemorrhage by traction on them along with support of the lobe from behind with the finger. The lobe is then encircled with an incision through the capsule just above the forceps. The resection is then made by wedging out the interior of the gland.
>
> "Starting at either pole, a continuous mattress suture of plain catgut from outer to inner capsule is inserted behind the line of forceps originally placed on the capsule and continued to the other extremity of the lobe. This controls practically all the bleeding and obliterates the cavity in the center of the lobe. The same suture, returning in an opposite direction, by a locking or button-hole stitch catches the edge of the capsule and rolls the two edges together into some semblance to a normal lobe."
>
> The opposite side is treated in the same way, resecting as much as seems necessary.

LIGATION OF SUPERIOR THYROID VESSELS

A transverse incision (Fig. 19) corresponding to a natural fold or crease of the skin is best, since it gives ample exposure and leaves the least scar. It is placed in general on a level with the middle of the thyroid cartilage, but the position is modified according to the size of the goiter. The situation of the upper pole should be estimated and the incision made over it. For unilateral ligation the incision extends from near the midline outward about 2 in. The skin, platysma and deep fascia are cut and dissected together upward and downward. The anterior border of the sternomastoid is retracted laterally and the omohyoid is drawn mesially. The upper pole and vessels are thus exposed (Fig. 20). A ligature of chromic catgut, linen thread (Mayo), or silk (Halsted) is passed around the vessels close to or including the pole and tied. If a vein is pierced the ligature should be drawn upon and another passed somewhat

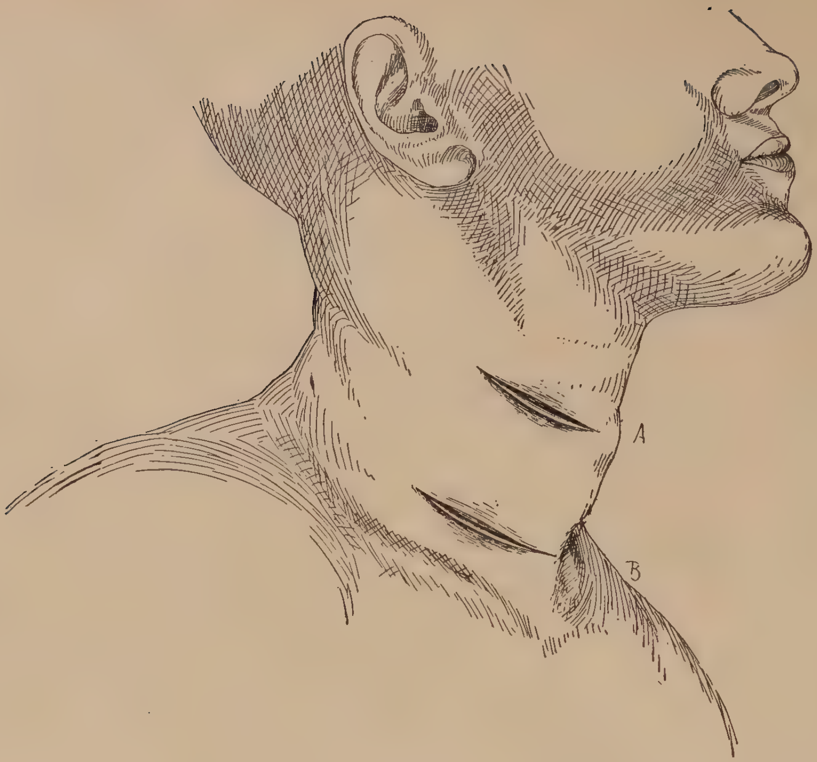


Fig. 19.—A, Incision for Ligation of Superior Thyroid Vessels; B, Incision for Exposure of Inferior Thyroid Artery, Anterior to Sternomastoid Muscle.

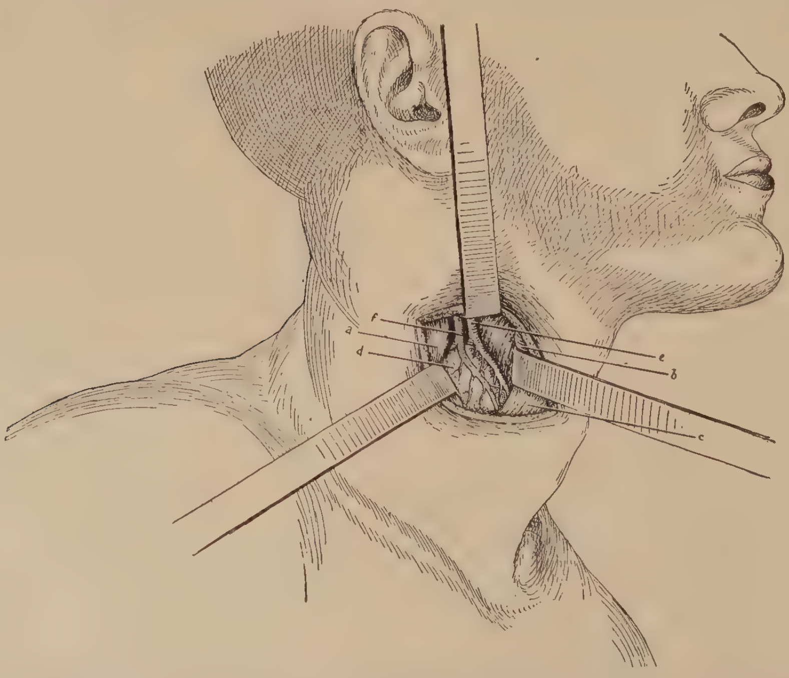


Fig. 20.—Exposure of Superior Thyroid Artery. a, Sternomastoid; b, anterior jugular vein; c, omohyoid; d, thyroid gland; e, superior thyroid artery; f, superior thyroid vein.

deeper (Mayo). Drainage is ordinarily unnecessary. The platysma and fascia are closed with interrupted sutures and the skin with subcuticular stitch.

For bilateral ligation Mayo recommends an incision about 2½ in. long with its center in the midline. This gives a good exposure. However, single incisions may be used to advantage especially in bilateral enlargements with high thick poles.

LIGATION OF INFERIOR THYROID ARTERY

There are 2 methods of approaching this vessel and each has strong supporters. In one the artery is approached anterior to the sternomastoid; in the other, from behind this muscle. An exact knowledge of the anatomy of the parts is mandatory in attempting either method. With such knowledge the posterior method is probably the easier; without such knowledge the anterior method is the least dangerous.

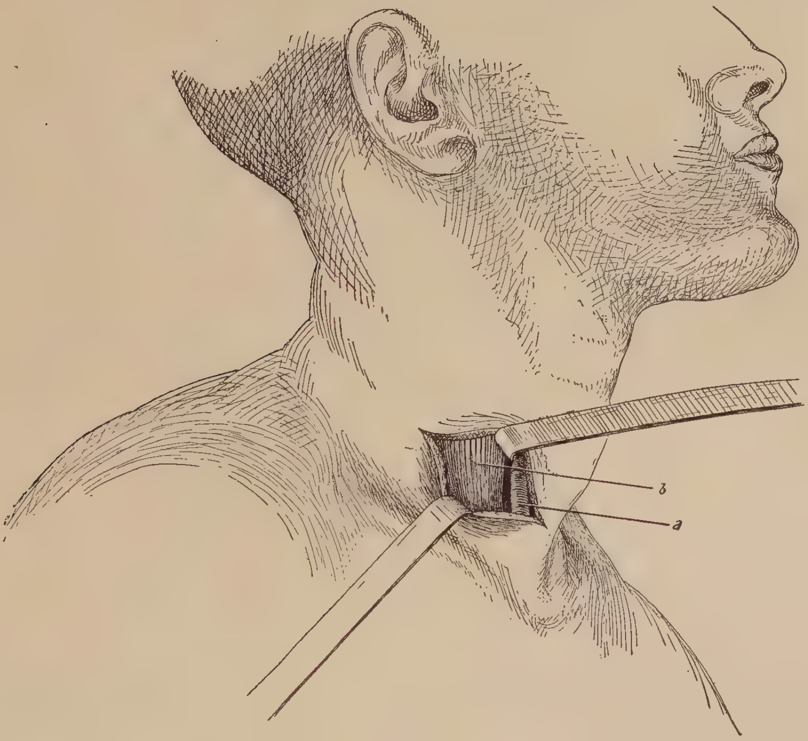


Fig. 21.—Exposure of Inferior Thyroid Artery (1). Flaps retracted. a, Anterior jugular vein; b, sternomastoid muscle.

1. **Anterior Operation** (Figs. 19, 21, 22, 23).—A transverse incision is made 2 to 3 cm. above the clavicle corresponding to a natural fold or crease of the skin, extending from the mid line well outward over the body of the sternomastoid muscle, the length depending upon the size of the thyroid lobe and

thickness of the tissues. The skin, platysma and deep fascia are incised and dissected together upward and downward. The edge of the sternomastoid is freed and retracted outward and the sternothyroid is retracted inward. The lower part of the thyroid gland is thus exposed and should be retracted somewhat forward and mesially; this opens the space between the mesial aspect of the carotid sheath and the thyroid gland. The inferior thyroid artery lies on a plane a trifle deeper than the common carotid and is covered by a fascial layer.

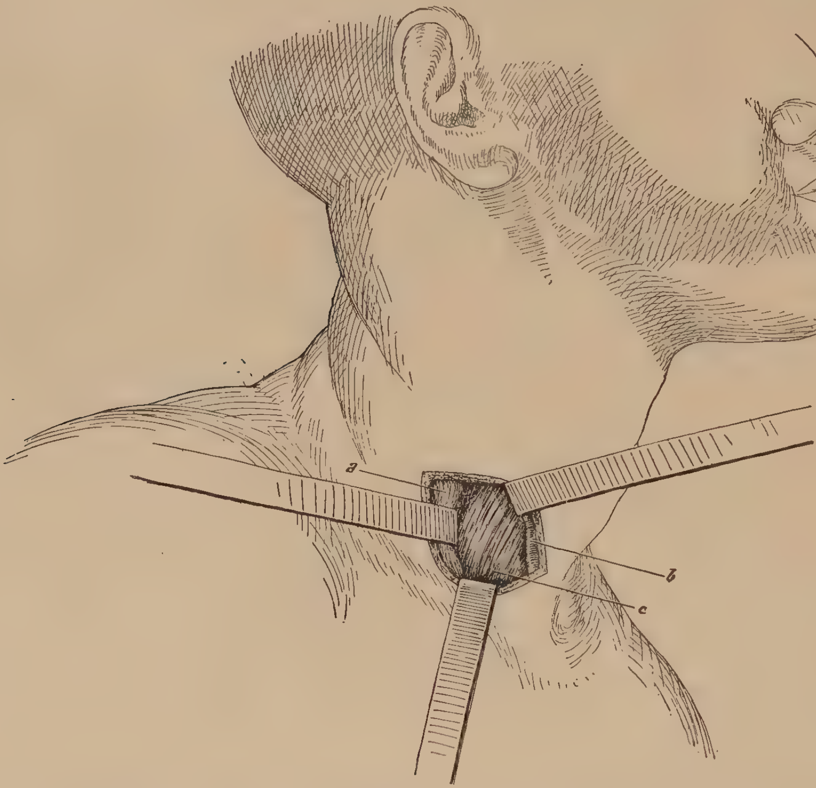


Fig. 22.—Exposure of Inferior Thyroid Artery (2). a, Sternomastoid; b, anterior jugular vein; c, sternothyroid muscle.

The vessel is much more difficult to expose than the superior. The mistake usually made is that it is sought too low. Under normal conditions its course is downward and inward from behind the carotid at a point approximately ½ the distance between the sternal notch and the lower edge of the cricoid cartilage. If these normal relations are borne in mind, its position may be better estimated under the conditions which prevail with an enlarged thyroid. In some cases a large vein, the middle thyroid, is encountered on a plane superficial to the artery passing outward anterior to the carotid artery to the internal jugular. This vein should be ligated if present. The inferior thyroid artery is not exposed until the fascial layer immediately internal to the carotid is split. The vessel is lifted with an aneurysm needle and ligated close to the carotid artery; injury to the inferior parathyroid and recurrent laryngeal is thus avoided. The closure of the wound is made as in ligation of the superior thyroid.

2. **Posterior Operation.**—I am indebted to Dr. John Rogers for demonstrating to me the value of this method and the relative facility with which it can be carried out. The incision may be oblique or transverse. Rogers, who employs the posterior route as routine under local anesthesia, uses the oblique incision; I have found the transverse incision equally satisfactory, with the advantage that it leaves a better scar. A transverse incision should be placed about 2½ cm. above the clavicle with its center corresponding to the posterior border of the sternomastoid muscle. The incision includes the skin, platysma and deep fascia; these tissues are freed together and retracted upward and downward. If an oblique incision is used, it is placed over the lower 2½ in. of the posterior border of the sternomastoid muscle; the fascia is incised near the external jugular vein, which is ligated if necessary. The subsequent steps are the same, irrespective of which incision has been employed. The sheath of the great vessels is exposed and retracted inward. The dissection is carefully continued until the outer edge of the scalenus anticus is exposed. This is the important

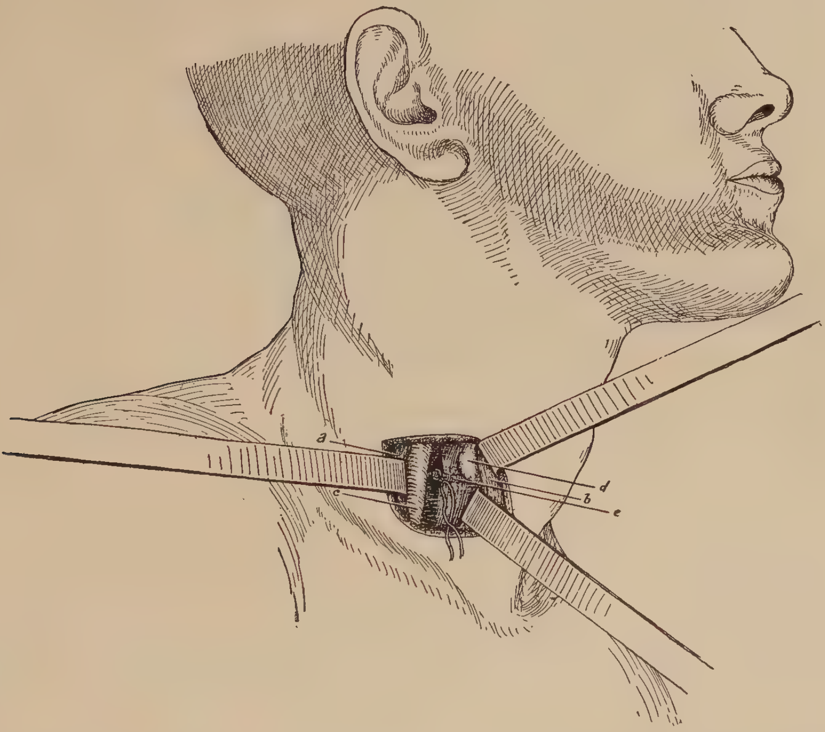


Fig. 23.—Exposure of Inferior Thyroid Artery (3). a, Sternomastoid; b, sternothyroid; c, common carotid; d, thyroid gland; e, inferior thyroid artery covered by fascia. The fascia has been split and a ligature passed around the artery.

landmark, and the remainder of the operation is comparatively easy. The dissection is continued bluntly inward along the anterior surface of the fascial layer which covers this muscle; injury to the phrenic nerve, which crosses the muscle posterior to this fascia, is thus avoided. The vessel sheath with its contents is drawn forward and mesially by a long right-angled retractor about ½ in. wide.

When the inner margin of the scalenus anticus is reached, the tissues internal to it are opened bluntly with the index finger and the inferior thyroid artery can be seen and felt behind a thin layer of fascia just internal to the mesial border of the muscle. The fascia is opened and the artery is raised with an aneurysm needle and ligated with chromic catgut. Extreme care is necessary in this step because the wall of the artery is thin and easily torn; moreover, the depth of the wound renders the control of hemorrhage difficult. The wound is closed without drainage, unless there is a probability of hemorrhage, in which case a rubber tissue drain should be inserted. The operation can be performed, with practically no suffering, under local anesthesia.

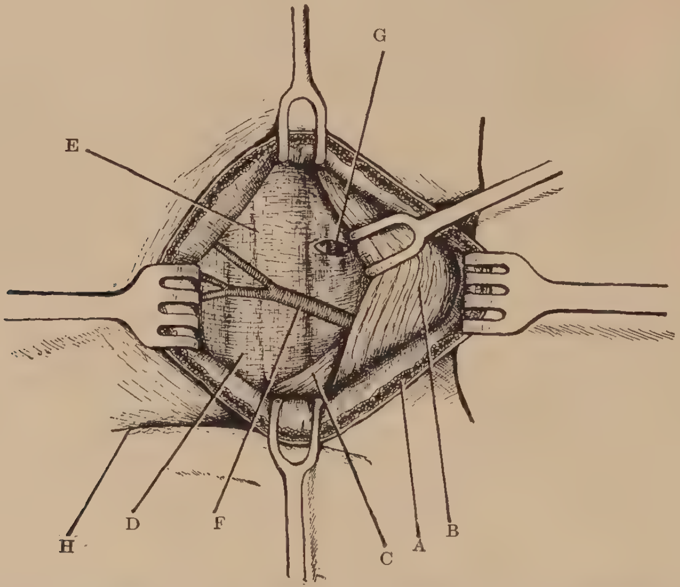


Fig. 24.—Exposure of Inferior Thyroid Artery by Posterior Route; Transverse Incision. A, Flap containing skin, platysma and deep fascia; B, sternomastoid; C, omohyoid; D, scalenus anticus covered with fascia; E, phrenic nerve beneath fascia; F, transversalis coli artery; G, inferior thyroid artery, through slit in fascia; H, clavicle.

ENUCLEATION

The part containing the nodule or nodules is freely exposed by a transverse incision following the method described under the technic of excision. Retraction or section of the depressors of the hyoid is elected according to the requirements of the case, depending upon the size, position and number of the adenomata or cysts to be removed. The gland having been exposed, the surgical capsule is incised, any veins encountered being carefully clamped and ligated. The true capsule and tissue of the thyroid overlying the nodule are incised until the nodule is reached. The wound in the gland is then stretched, rather than cut, to an appropriate size by inserting and opening an instrument such as scissors. The nodule is carefully shelled out with an enucleator or the finger. Deep mattress sutures of catgut are then inserted to approximate the sides of the space and control oozing. Drainage should be provided if there is a large area of raw tissue or a probability of hemorrhage. The drain may be gauze, "cigarette" or preferably a tube with rubber tissue as described on page 305. The wound is closed in the same manner as in excision. The procedure is not devoid of danger chiefly by reason of hemorrhage, which may be immediate or secondary. The method is only applicable to nodular and cystic goiters.

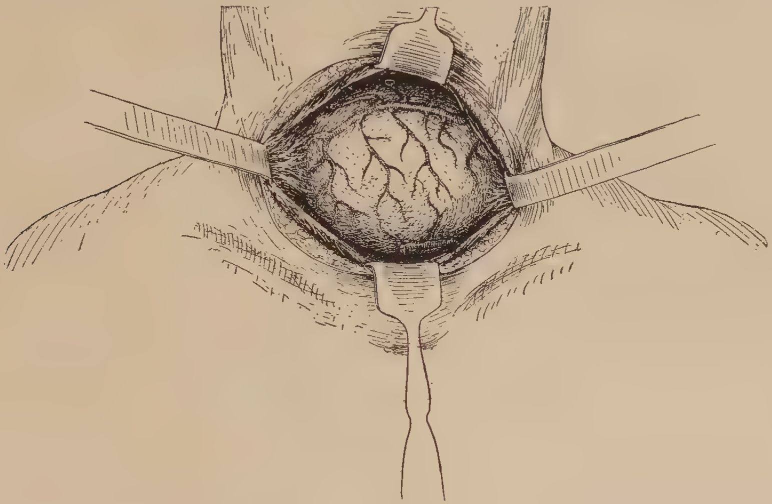


Fig. 25.—Enucleation of Adenoma. Drawing made at operation. Transverse incision, retraction of muscles.

EXENTERATION

Expose as in enucleation. The nodule is incised and the contents turned out with the finger or with an instrument, such as an enucleator or curet, and the wound drained. Specific details are given under intrathoracic goiter, page 314.

ACCESSORY OR ABERRANT THYROIDS

Lingual Thyroid (Lingual Goiter).—Thyroid tissue occasionally occurs in the posterior third of the tongue. It may represent an accessory thyroid or a misplaced gland, of normal or pathologic structure, which has developed in a high position as a result of an undescended stalk. Clinically it presents as a smooth, rounded, elastic, slow-growing, painless tumor beneath the mucous membrane near the base of the tongue. It projects upward and backward between the pillars of the fauces and may obstruct the pharynx to a variable degree, causing difficulty in swallowing, respiration and phonation, though the symptoms are not as a rule marked. The tumor may also be evident as a bulging beneath the chin. Removal of the tissue is indicated if there is discomfort, sudden or rapid increase in size or interference with deglutition, respiration or speech. But a benign growth should not be wholly removed unless there is assurance of the existence of thyroid tissue elsewhere. In case of doubt, an incision should be made to demonstrate the presence or absence of a gland in the normal position; if none is present, the lingual thyroid should not be operated upon unless the symptoms are urgent, in which case only a resection should be made. If the tumor is malignant the entire mass should be removed by radical operation.

OPERATION.—The growth may be removed from within the mouth or from beneath the chin. The latter appears from reports of cases to be rather more satisfactory by reason of easier exposure and greater facility in the control of hemorrhage. However, the method elected must be based upon the conditions of the case.

External Operation.—An incision is made in the mid line from the chin to the hyoid bone and is deepened until the mylohyoid is divided; the underlying muscles are then separated and the capsule of the tumor exposed. The procedure at this stage is simplified by downward pressure upon the mass by a finger in the mouth. The capsule is incised and the tumor enucleated. Considerable bleeding is said to occur. The mucous membrane is often opened. Temporary packing and ligatures control the bleeding. Deep sutures of catgut are inserted and drainage instituted if bleeding is not controlled or the mucous membrane opened.

Internal Operation.—The tongue is drawn well forward by suture-tractor, the jaws are widely opened with a gag, and a median incision is made over the tumor, which is enucleated with the finger.

Intrathoracic Goiters.—These may be solid or cystic; they may develop from the thyroid, to which they remain attached by a stalk of variable size, or they may develop independently, presumably in an accessory thyroid, and be entirely separated from the gland. Prior to the development of pressure symptoms an intrathoracic tumor or cyst may be readily overlooked both before or even during operation. Pressure symptoms, when they have once begun, increase slowly but progressively and are likely to reach a serious degree of dyspnea by reason of the confined position of the growth rather than its size.

TREATMENT.—Relief of pressure is imperative; but, on account of the inaccessibility of the growth, complete extracapsular removal can rarely be carried out with safety. If extracapsular removal is not feasible a *solid growth* should be treated by exenteration, that is, it is incised and its contents turned out from within the capsule. The removal of the tissue is made with finger or instrument, the tissue being removed either as a whole or piecemeal. The cavity may be packed loosely with gauze which is gradually removed or, as Mayo suggests, a small drain may be inserted and removed in about 24 hours. He argues that an uninfected blood clot is thus obtained and a persistent sinus avoided. A *cyst* should be incised, its wall sutured to the skin and drainage introduced. These procedures relieve pressure symptoms immediately. The cavity rapidly diminishes in size and, as a rule, the sinus closes within a few months (Martin).

Lateral Accessory or Aberrant Thyroid.—Masses of thyroid tissue not connected with the thyroid gland may occur in other situations than the tongue and mediastinum. Their most frequent sites have been described under anatomy. A lateral accessory or aberrant thyroid may call for operative intervention for cystic, benign solid, or malignant growths. The tumor occurs most frequently beneath the sternomastoid muscle but projects into the lower part of the anterior triangle of the neck. Operative procedures depend upon the size and position of the tumor. The incision, if possible, should be transverse in a natural crease of the skin, but for large or malignant growths it should be oblique along the anterior border of the sternomastoid. The mass may be readily exposed, dissected free and removed, after ligation of its vessels (Schrager, Cushway).

I presented a case of carcinoma of an accessory thyroid before the New York Surgical Society, 1910.

The patient was a woman, 46 years old. For 3 years she had noticed a swelling on the left side of the neck which had gradually increased in size. At the time of admission to the New York Hospital she had pains of great severity in the left shoulder. She had lost about 30 pounds in weight.

On the left side corresponding approximately to the lower 2/3 of the sternomastoid muscle, there was a swelling about 3½ inches in diameter. The swelling, which lay in part beneath the sternomastoid muscle, was hard, slightly nodular, and somewhat movable, but did not move during deglutition.

Operation by Dr. Hartley. The mass was exposed by an incision along the anterior margin of the sternomastoid. The internal jugular crossed it vertically, and was ligated above and below; the omohyoid also crossed it, and was divided. The mass was then readily enucleated, after ligating several large nutrient vessels. The carotid lay posterior to the growth, the sternohyoid and sternothyroid mesial to it. On lifting these, the whole of an apparently normal thyroid gland, with isthmus and pyramidal lobe, was exposed. The patient made an uneventful operative recovery.

Report on specimen, made by Dr. Elser. The specimen consisted of an aberrant thyroid gland, oval in shape, measuring 9.5 cm. in length, 5.5 cm. in breadth, and 5 cm. in thickness. The mass was covered on the outside by connective tissue membrane, through which numerous large, vascular channels were dispersed.

Microscopical examination revealed the typical histology of papillary adenocarcinoma. Microscopical examination of the lymph-nodes revealed extensive metastatic deposits. Practically all the lymphoid tissue had been replaced by tumor growth.

INFLAMMATION OF THE THYROID

Acute inflammation of the thyroid gland is one of the least common affections of the gland. An acute inflammation may occur in a normal or a goitrous gland. The former is known as *thyroiditis,* the latter as *strumitis.* The condition may develop with no apparent exciting cause, but usually occurs in the course of an acute febrile disease. In acute inflammations of the thyroid both sides are usually affected but one side more than the other. The process may result in resolution, in suppuration or in gangrene. It is said that thyroiditis associated with mumps, influenza, malaria, rheumatism, and tonsillitis usually resolves; and when associated with pneumonia, puerperal fever, the majority of typhoid cases, diphtheria and erysipelas, suppuration usually occurs. Gangrene is rare. When resolution occurs, the average duration is 14 days, the swelling reaching the maximum on the third or fourth day. When suppuration occurs, on account of the resistance of the capsule the pus may burrow in any direction and may perforate into the trachea or esophagus or penetrate into the mediastinum. The prognosis in non-suppurative cases is good as to life and return of the gland to normal. In suppurative cases the prognosis is not so good; of 41 cases, 9 died, 22 per cent. (Robertson). In the gangrenous variety the outlook is very poor; of 9 cases all were fatal (Richardson, Robertson).

Treatment.—Prior to suppuration, thyroiditis should be treated by wet dressing, ice bag, etc., with appropriate treatment of the associated disease. Suppuration demands immediate incision and drainage. A transverse incision, corresponding to a natural crease of the skin, should be used if possible. The dissection often must be carried to a considerable depth before the pus is reached. On incising and draining abscesses of the thyroid, it has been found that they are prone to bleed freely. Kocher recommends complete extirpation of the diseased part. This procedure is doubtless preferable in cases of strumitis but is somewhat heroic in cases of thyroiditis. Tracheotomy should be resorted to for dyspnea only as a last resort.

Chronic (Woody) Thyroiditis.—An unusual form of chronic thyroiditis has been described. The reader is referred to Reidel, who, in 1896, first described the lesion, and to Murray and Southern for a case report.

TUBERCULOSIS OF THE THYROID

Tuberculosis of the thyroid gland is almost always secondary to tuberculous lesions elsewhere; extremely few cases of primary tuberculosis of the thyroid have been reported.

Secondary tuberculosis of the thyroid may be divided into 2 classes: the chronic type with caseous nodules or abscess formation, and the acute miliary type.

Chiari, in 100 autopsies on tuberculous patients, found tuberculosis of the thyroid 7 times; caseous nodules 4 times (in 96 chronic tuberculous cases), and miliary tubercles 3 times (in 4 acute miliary cases).

In the acute miliary type tubercles are found in the thyroid at autopsy, having given no signs during life. The chronic type may give no symptoms other than a nodular enlargement of the thyroid, which usually leads to a diagnosis of goiter. If operation is performed the true condition is, as a rule, first recognized when the gland is exposed. If early operation is not undertaken, an abscess usually develops and may perforate into one of the neighboring structures. Rolleston reports a case which perforated into the esophagus, although it had given rise to no subjective symptoms. If the nodules increase sufficiently in size they may cause symptoms of compression.

Treatment.—If the condition is first recognized after exposing the gland, complete excision of the part containing the tuberculous foci is indicated, provided other tuberculous lesions are not far advanced and provided the operation will not sacrifice a dangerous amount of the gland. Abscess formation demands early drainage to avoid perforation into adjacent structures.

MALIGNANT GROWTHS OF THE THYROID

Malignant growths of the thyroid gland are rare. They usually develop in a goitrous gland but occasionally originate in a normal gland. Both carcinoma and sarcoma occur, carcinoma being the more frequent.

Carcinoma.—Carcinoma presents 2 groups (Marine and Lenhart); one in which the growth follows the general characteristics of fetal thyroid and one in which the follicles are more differentiated. Some specimens of the second type present a structure which has been designated "papillary cystic carcinoma." The histological diagnosis of carcinoma of the thyroid is said to be difficult in many cases, a feature which should be remembered when a frozen section diagnosis is called for.

"In the majority of cases the tumor, from its point of origin, infiltrates one entire lobe of the thyroid and may extend across the isthmus to the other lobe, but extracapsular growth is delayed for some time. The capsule finally becomes perforated by the growing tumor, but only at a single point at first and not diffusely" (Müller and Speese). The trachea and other structures are frequently infiltrated, and even penetrated, rather than displaced to a marked degree. The great vessels are often surrounded by the growth. A malignant tumor may not be fixed to the surrounding tissues to such an extent as to interfere with the movement of the thyroid in deglutition and yet may be so firmly attached to the trachea as to be inseparable from it. Such was the condition in a case reported by Meyer.

Distant metastases occur through the blood-vessels with relative frequency. Metastases occur most frequently in the bones and are often solitary and slow growing. Secondary growths in the viscera are next in frequency. Metastases may occur while the original tumor is of small size.

SYMPTOMS AND DIAGNOSIS.—The patient is usually over 40 years of age; the thyroid, which is as a rule the seat of a goiter, increases in size comparatively suddenly and rapidly and is usually nodular, hard and painful. Paralysis of the recurrent laryngeal nerve is relatively frequent. The neighboring lymph-nodes become enlarged, but this feature offers little aid in diagnosis since the character of the thyroid tumor is usually recognized before they are enlarged; moreover, the nodes first involved are frequently inaccessible, lying deeply either at the root of the neck or within the mediastinum. Metastases in the bones may be the first sign of a malignant growth of the thyroid.

OPERATIVE TREATMENT.—Success depends upon early diagnosis and early operation. Some surgeons recommend complete thyroidectomy, but the majority, among others Berry, consider that complete extirpation of the gland is rarely desirable because, if both lobes are involved, the tumor is usually so firmly attached to the trachea that it cannot be satisfactorily removed.

Extensive involvement of adjacent structures, such as the great vessels, esophagus, trachea, larynx, or pharynx, and extension into the thorax contra-indicate operation. In slight involvement of adjacent structures "the extent of the operation must depend upon the operator's judgment" (Kocher). Successful excisions of portions of the walls of the trachea and esophagus have been performed; if the lymph-nodes appear to be involved, they should be removed in a mass dissection. Kocher does not consider that a single bone metastasis is a contra-indication to operation because it is often solitary, of slow growth, and may occur before the primary growth is extensive. He advises excision of the bone metastasis and operation upon the gland if the condition of the patient and the extent of the growth warrant the operation.

PROGNOSIS.—If the growth is limited to one lobe, if the capsule has not been penetrated, and if there is no evidence of lymphatic involvement or other metastases, the prognosis is relatively good, according to Kocher. Recurrences are usually local. The papillary cystic type of carcinoma offers the best prognosis. Recurrence in this type is usually late and of slow growth.

If the growth has extended beyond the capsule and involves adjacent structures, or if there are metastases other than a solitary bone metastasis, operation is unlikely to effect a cure.

PALLIATIVE TREATMENT.—In advanced cases in which a radical operation is contra-indicated, pressure symptoms, of which the most frequent and serious is dyspnea, may demand relief. Tracheotomy, excision of part of the growth, and division of the isthmus are the procedures to be considered. Of these, resection is to be preferred. Tracheotomy is frequently extremely difficult in this class of case because of the size and position of the growth, the large size of the veins, and at times the displacement of the trachea. It may, however, be the only practical means of relieving the dyspnea. When tracheotomy is indicated, it is sometimes necessary to make the incision directly through the tumor; under such conditions König's long flexible silver tracheotomy tube may be used advantageously. Division of the isthmus is not likely to prove effective.

Sarcoma.—Sarcoma is even less frequent than carcinoma. Clinically the 2 conditions cannot be differentiated. The general rule that sarcoma occurs in younger individuals than carcinoma has no significance in thyroid growths. "Sarcoma may be disseminated through the lymphatic channels with greater frequency than is the usual rule" (Müller and Speese). The details of operative treatment discussed under carcinoma apply in general to sarcoma.

DEFICIENCY OF THYROID AND PARATHYROID SECRETION

Various clinical manifestations have been ascribed to deficiency of thyroid or parathyroid secretion; in some the relationship has been proved, in others it is hypothetical. Of these conditions the ones which should be dwelt on from a surgical standpoint are postoperative tetany and cachexia strumipriva.

TETANIA PARATHYREOPRIVA AND CACHEXIA STRUMIPRIVA

Appreciation of the significance of tetania parathyreopriva and cachexia strumipriva is vital to the surgeon. Only a realization of the seriousness of these conditions can lead to persistent and effective efforts in the direction of prophylaxis, of which the importance cannot be too strongly emphasized. Although these complications of thyroid operations are rare, a fairly extensive analysis of them is essential in connection with the study of the surgery of the thyroid gland.

General Considerations.—The occurrence of tetany after operations on the thyroid gland was first recognized by Weiss in 1880. About three years later Kocher and Reverdin called attention to the condition since known as cachexia strumipriva. This was shown by Kocher to be a frequent sequel to complete thyroidectomy. The 2 diseases, tetany and cachexia strumipriva, were regarded for a considerable time as different phases of one condition which was supposed to be dependent upon functional insufficiency of the thyroid gland.

Schiff, in 1884, showed that certain animals, notably cats and dogs, regularly died after complete removal of the thyroid. In consequence of the dire effects which were thus noted experimentally as well as clinically after complete thyroidectomy, it became a surgical mandate that part of the organ should be spared in goiter operations. This precept, which was fathered by Kocher, has prevailed up to the present time and its practice accounts for the relative infrequency of cachexia strumipriva, also indirectly of postoperative tetany.

In animal experimentation a perplexing inconsistency prevailed by reason of the fact that total thyroidectomy in carnivora was followed by fatal tetany, whereas in herbivora it was followed by the more protracted cachexia strumipriva with no evidence of tetany. Gley, in 1891, explained the peculiar difference in the reactions of these 2 classes of animals to the removal of the thyroid. He called attention to the existence in the rabbit of 2 isolated bodies, the external parathyroids, and demonstrated that the removal of these together with the thyroid produced the same effects as complete thyroidectomy in other animals.

The first practical step toward ascribing to the parathyroids an independent potency resulted from the work of Vassale and Generali, 1896. They demonstrated by striking experiments that, the thyroid being preserved, removal of the 4 parathyroids led to fatal tetany; while no tetany resulted from the removal of the thyroid if the parathyroids were left.

It has been urged by numerous experimenters that the intensity of the tetany stands roughly in inverse ratio to the number of healthy parathyroids retained by the animal. But this rule is certainly far from absolute, for sometimes the presence of 1 parathyroid is sufficient to prevent the symptoms of tetany, while in other cases 2 of the organs are necessary (Erdheim).

Thyroidectomy alone, especially in young animals, gives rise to troubles of nutrition. The animals remain undersized, their behavior is altered and sluggish, the skin becomes thick and edematous, and the hair coarse. These changes begin in less than a month after the operation. On the other hand, parathyroidectomy produces a more rapid onset of symptoms. These include fibrillary twitchings, tremors, local or general contractions (tonic or clonic), convulsions, dyspnea, tachycardia, ptyalism, thirst, vomiting, diarrhea, general weakness, and prostration. The results of the long series of animal experimentation bearing on tetany have been corroborated by significant findings of Erdheim, Pineles, and others in man.

In a word, cachexia strumipriva or operative myxedema, which is a disturbance of metabolism, is unquestionably due to removal of the thyroid. Postoperative tetany, which is a convulsive disturbance suggestive of a toxemia, is regarded by almost all observers as due to an insufficiency of parathyroid activity resulting either from removal of the parathyroids or impairment of their functional capacity by injury to or interference with their blood supply.

As Jeandelize summarized (1903), the thyroid and parathyroids are different organs; the results of ablation of the 2 are not the same; physiologically the 2 organs are correlated, yet neither can assume the functions of both.

Pineles analyzed 13 cases of tetany (1904) following partial thyroidectomy. Six had undergone extirpation of both lobes, 3 extirpation of 1 lobe and isthmus, in 4 only the upper portion of 1 lateral lobe had been left. On the basis of these cases he emphasized the fact that tetany is most likely to follow a partial thyroidectomy in cases in which only the isthmus or upper parts of the lateral lobes are left, because such procedures favor extirpation of or injury to the parathyroids.

Illustrative Cases.—Two cases of tetany following operations for recurrent goiter have come under my observation, the first in my own service, the second in that of a colleague. These cases will be briefly reviewed because they give a live and, for the purpose of this article, a sufficient elaboration of the features which are of practical importance to the surgeon, namely, the symptoms, course, and diagnosis of the condition.

CASE 1.—April, 1906, French Hospital, seamstress, Swiss, 33 years of age. In 1903 the patient suffered from marked dyspnea and dysphagia. Previous to that, there had developed a large goiter. The left lobe of the thyroid was removed by another surgeon. During the second year after operation a swelling developed in the mid line and dyspnea and dysphagia recurred, increasing to such degree that operation became imperative.

In March, 1906, I operated under ether anesthesia. In the region of the isthmus there was a round, smooth mass, about 2½ in. in diameter, which was bound down by cicatricial tissue; it extended downward behind the sternum and compressed the trachea. The left lobe of the thyroid was absent. Before any tissue was removed the right lobe was thoroughly exposed and found to be of normal size, appearance and consistency. In removing the mass, the thyroid gland was clamped at the junction of the isthmus and the right lobe, and cut across as close to the tumor as possible. Before doing this it was found necessary to ligate the inferior thyroid artery which ran close to the mass. The whole of the right lobe, except a small part which lay close to the isthmus, was left.

Postoperative Course.—The healing of the wound was uneventful. On the fourth day after operation, tetanic contractures occurred in both hands, which assumed an attitude similar to that produced by stimulation of the ulnar nerve. The spasm was accompanied by cramp-like pains. This condition was present whenever the patient was seen during the next 24 hours, when cramps in the feet and calves also occurred, together with forcible plantar flexion of both feet lasting for about 5 minutes.

For 13 months the patient presented the typical clinical features of tetany. The most conspicuous symptoms were bilateral and symmetrical contractions of the flexor muscles of the hands, wrists and feet, as previously described, preceded and accompanied by cramp-like pains in the affected parts. At times the contractures were more generalized. For several weeks there was marked edema of the left wrist and hand, and redness over the knuckles. During the whole period Chvostek's and Trousseau's signs were present and typical. Thus, the facial muscles contracted rapidly to mechanical irritation by tapping over the facial nerve (Chvostek); and the usual contractures of the hands were brought on in about ½ to 3 minutes by steady pressure on the nerves and vessels of the arm (Trousseau). In the latter test, cramp-like pains regularly preceded the spasm which developed gradually and not suddenly. Contractures also resulted from making the sciatic nerve tense (leg phenomenon). Similarly, contractures occurred as a result of putting the nerves of the brachial plexus on the stretch (arm phenomenon). The contracted muscles were always board-like to the touch.

The above symptoms occurred in attacks at variable intervals. During the first 6 weeks and the last 3 months of the disease, there were from 1 to 5 attacks almost every day. The duration was from several minutes to several hours. During the intervening months the patient was not under observation; the attacks, however, rendered any work impossible.

The attacks of tetanic spasms gradually ceased; Chvostek's and Trousseau's tests and the leg and arm phenomena became less marked, and finally elicited no responses.

As therapeutic measures, various thyroid and parathyroid preparations were administered by mouth and hypodermatically, and 5 parathyroids were implanted subcutaneously. These were removed aseptically, immediately after death, from 3 accident cases, put at once into ascitic fluid, and implanted as soon as possible into subcutaneous tissues.[1]

The improvement in the symptoms and disappearance of the tests for tetany were coincident with the repeated administration of Beebe's nucleoproteid in large doses hypodermatically, and occurred from 4 to 6 weeks after the first implantation. No effect could be attributed to other therapeutic measures.

The occurrence of tetany in this case may be explained as follows: At the first operation two parathyroids were probably removed with the left lobe of the thyroid. Since no symptoms occurred until after the second operation, this undoubtedly was the cause, presumably through the sacrifice of sufficient parathyroid tissue to upset the functional equilibrium which must have been very unstable as a result of the previous operation. It is not possible that both the remaining parathyroids were sacrificed, for in that case a fatal tetany would undoubtedly have resulted. Since no parathyroid tissue could be found in the mass removed, it is probable that either the inferior parathyroid of the right side was crushed in the clamp, or that the blood supply of one or both of the parathyroids on this side was interfered with by the ligation of the inferior thyroid artery.

CASE II.—In contrast to the first case, the second presented a short course, yet it afforded an opportunity to study the characteristic diagnostic features of tetany, which are dependent upon hyperirritability of the motor nerves.

The patient was a well-developed intelligent woman 22 years of age, who had undergone 2 operations for goiter in Europe, 5 and 8 years previously. Her general health had always been good and nervous system normal. On February 1, 1912, a third operation on the thyroid gland was performed by another surgeon. The right lobe was removed in toto, only the isthmus being left. Both the superior and inferior thyroid arteries of the right side were ligated. The left lobe of the gland had evidently been excised at a former operation, as inspection of this side is said to have revealed no evidence of thyroid tissue. Moreover the 2 parathyroids of the left side presumably had been removed, otherwise tetany could scarcely have followed this third operation. The healing of the wound was uncomplicated. Not being present at the operation, we were unable to secure the tissue removed to examine it for parathyroids. The pathologist's report stated that the specimen consisted of a lobulated mass which revealed the picture of adenoma of the thyroid.

On the *third day* after operation, February fourth, tonic contractures occurred with cramp-like pains in the fingers and hands, which assumed the position known as accoucheur's hand. The patient also had cramp-like pains in the calves.

On the *fourth day*, February fifth, calcium lactate (36 grains) was given hypodermatically at 2 P. M. There were tonic contractures of the fingers of the left hand with cramp-like pains lasting from 9 P. M. to 1 A. M.

We saw the case for the first time at noon on February fifth and made electrical and

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[1] Thanks are due the publishers of the *Annals of Surgery* for permission to reproduce extensively in this paper parts of articles and case reports which have appeared in that journal.

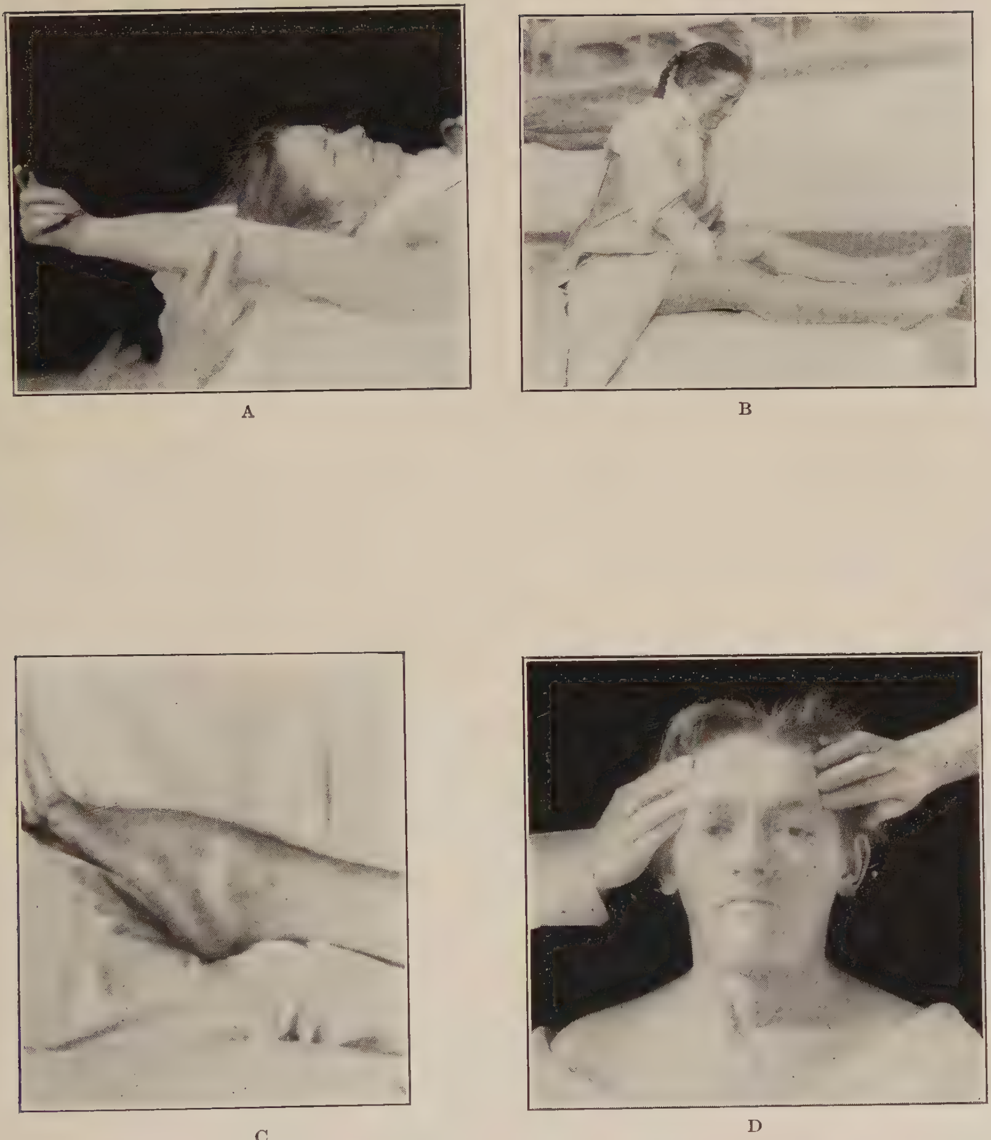


Fig. 26.—Case II.—Postoperative Tetany. A. Arm phenomenon, showing contractures of fingers as a result of extreme abduction of arm with elbow extended. B. Leg phenomenon, showing plantar flexion of right foot, as a result of forcible flexion of trunk upon thighs with knee extended. C. Contraction of the foot in the leg phenomenon. D. Postoperative myxedema.

other tests, finding an astonishingly marked hypersensitiveness of the motor nerves as indicated by Erb's, Trousseau's, Chvostek's tests and the leg and arm phenomena. The results of the various tests on this and subsequent days are given with the diagram of the electrical reactions (Fig. 27). Photographs (Fig. 26, A, B, C) were taken in the free intervals to show contractures characteristic of the arm and leg tests. On February sixth, calcium lactate (40 grains) was given by mouth at 9 P. M.

Sixth day, February seventh. Implantation of a parathyroid removed from a young male in an operation for simple goiter. The implant was placed in the properitoneal tissue behind the right rectus sheath.

Seventh day. Forcible contractures with severe pains in the parts affected. The elbows were flexed at a right angle; wrists and fingers were also forcibly flexed (accoucheur's hand). The attack continued from 5 A. M. to 11 A. M.

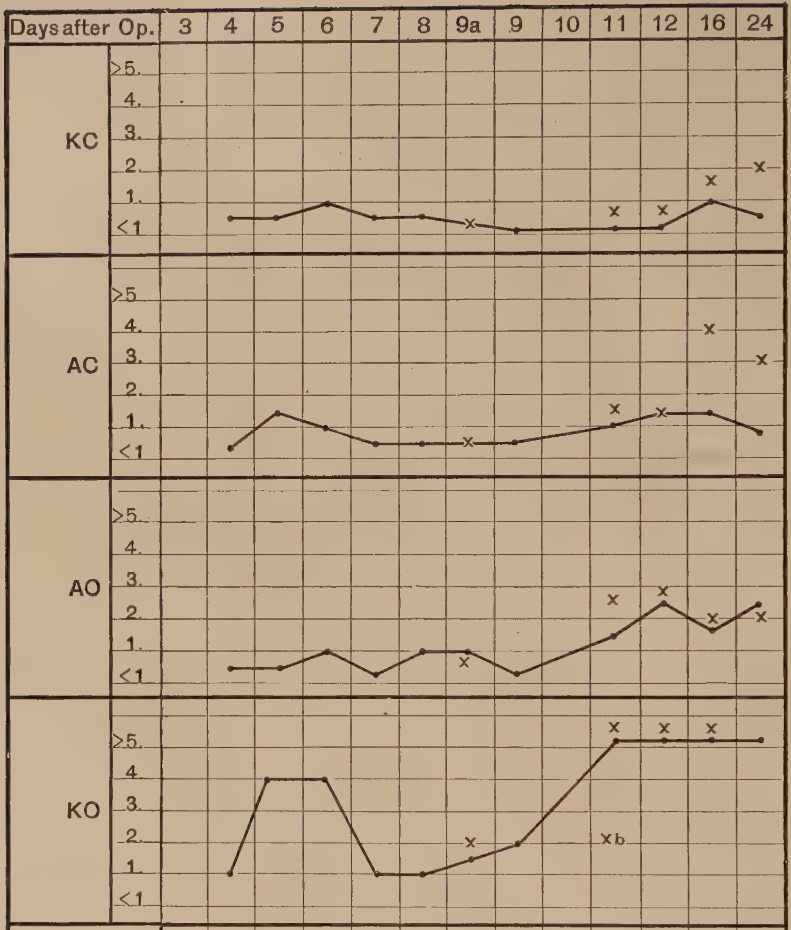
No further attacks of tetany were noticed up to the time of the patient's discharge. Shortly after her discharge she had 1 brief attack lasting about a minute, characterized by pain and contractures in right calf.

The woman subsequently developed symptoms of hypothyroidism (Fig. 26, D) with dry thick skin, dullness of mind, etc., and was put upon thyroid therapy. She has married and successfully passed through a pregnancy. When last seen (June, 1914) she had a tumor of considerable size corresponding to the isthmus of the thyroid, her general condition was good and the signs of hypothyroidism had for the most part disappeared, although she has ceased taking thyroid extract (Pool and Turnure).

DIAGNOSTIC TESTS OF TETANY BASED ON STUDIES IN CASE II—ELECTRICAL TESTS: ERB'S TEST.—Careful and repeated electrical tests were made with the galvanic current, thus obtaining an accurate chart (Fig. 27) of the changes of excitability, against which the other tests could be checked. By this means it was possible to compare the relative sensitiveness of the tests for this condition. Hyperexcitability of the motor nerves to the galvanic current was striking. As noted in the chart, the most significant changes from normal were the very low anodal opening and cathodal opening currents by which contractions were excited; but the cathodal closing and anodal closing currents were likewise abnormally low.

The two administrations of calcium temporarily lessened the hyperexcitability, as is shown by a rise from 1 to 4 milliampères in the cathodal opening current necessary to cause a contraction. Such effects are in keeping with the experimental findings of Voegtlin and MacCullum. They state that in dogs injections of calcium and likewise of strontium or magnesium always cause a disappearance of the symptoms of tetany, and, moreover, greatly lower the excitability of the nerves, not only in dogs in tetany, but even in normal dogs. Therapeutically they consider calcium the best drug for tetany, but do not favor its subcutaneous administration because of its irritating local effect upon the tissues. After implantation of the parathyroid the reactions gradually approximated normal; whether this was a coincidence or cause and effect cannot be stated.

In taking the electrical reactions, the ulnar nerve was always tested, and the external popliteal was also frequently employed as a check. Individuals not suffering from tetany were tested as controls. In the case of the ulnar nerve 1



Days after Op.	3	4	5	6	7	8	9a	9	10	11	12	16	24
Attacks	+	+	○	○	++								
Tests													
Chvostek		++	++	++	++	+	++		++	+	−c	○	
Trousseau		++	++	++	++	+	○		○	○	○	○	
Arm		++	++	++	++	+	○		○	○	○		
Leg		++	++	++	++	++	++		+	○	+d	○	
Tongue					○	○	○			○	○		

Parathyroid Implantation
Calcium Lactate by mouth (XL grains)
Calcium Lactate Subcutaneously (XXXVI grains)

FIG. 27.—ELECTRICAL REACTIONS AND TESTS IN TETANY. CASE II. Lines indicate excitability of ulnar nerve. X in diagram indicates excitability of external popliteal nerve. 9a. Tests made by Dr. Wilcox on ninth day with his own milliampèremeter to check our results. Xb. At 2 milliampères the current became too painful to go higher. c. Very slight response. d. Typical contractures occurred in 2 minutes in right foot, with severe cramp-like pains.

electrode was placed over the nerve just above the internal epicondyle and the other on an indifferent point at a distance, as the infraclavicular region. In the case of the external popliteal, 1 electrode was placed on the nerve behind the head of the fibula and the other on the abdomen. Hyperexcitability was evidenced by contracture to very slight stimuli, K C, A C, A O, and K O all being very low. The patient's responses to the 4 stimuli were constantly below the responses of the controls who were not suffering from tetany. The most marked and significant feature was the low K O currents. A cathodal opening current below 5 milliampères is particularly significant.

Erb's test is undoubtedly the most reliable and accurate for tetany. It should always be used in a suspected case since it gives an exact indication of the motor excitability and renders it possible to check daily changes in this excitability, thus obtaining a real index of the progress of the disease and the effect of therapeutic measures.

No attempt was made to obtain and study tetanic contractions with low currents, first, because of the mental unrest and physical pain which are likely to ensue, and, second, because this feature appears to us an unnecessary refinement since the electrical hyperexcitability is already established. Tetanic contractions, however, at times resulted from very low currents.

THE LEG PHENOMENON.—The leg phenomenon was first described by Pool in 1907, and has since been noted by Schlesinger and others. For this test the patient is placed in a sitting position with legs fully extended upon the thighs; the trunk is forcibly flexed upon the thighs by pressure exerted between the shoulders. The contractures are preceded and accompanied by pain, which may be severe enough to cause the patient to cry out. The feet become forcibly flexed (plantar) and adducted, assuming a position of marked equinovarus. This position cannot be altered by passive efforts, however forcible. The muscles of the calf stand out conspicuously and become board-like to the touch. The onset of pain and contractures begins from about 40 seconds to 2 minutes after the position is assumed. The pain becomes so severe in a short time as to make it imperative to desist.

The leg test, like *Trousseau's sign,* is dependent upon the hyperexcitability of the motor nerves. They differ only as to the method of demonstrating this hyperexcitability. In Trousseau's test the nerve is compressed, in the leg test the nerve is stretched. From the experience of our 2 cases it would appear that the leg test is as simple of application as Trousseau's sign and more sensitive and reliable. In the second case it was positive after Trousseau's test failed to elicit a response. Schlesinger considers the leg phenomenon pathognomonic of tetany.

THE ARM TEST.—The arm test consists in putting the nerves of the brachial plexus on the stretch by elevating the arm above the head with the forearm extended (extreme abduction). The characteristic contractures of the fingers, hand, and wrist occur with pain, as in the leg test. This test was likewise noted in my first case. It appears less sensitive than Trousseau's sign or the leg test, probably because it is not as easy of application. Further, it is difficult to avoid pressure over the ulnar nerve while holding the elbow extended and the limb in abduction.

CHVOSTEK'S TEST.—Chvostek's test was repeatedly present in our case, as indicated in the chart. It is a constant and sensitive test, but the duration of the contraction is short and therefore may be difficult to distinguish in doubtful cases.

HOFFMAN'S TEST.—Hoffman's test, which depends upon hyperexcitability of the sensory nerves to electrical and mechanical stimuli, was not studied. This test appears to be of little practical importance.

DAS PERONEUS PHÄNOMEN (LUST).—This test should be mentioned, although it was not applicable in our case. The peroneal nerve is struck with a percussion hammer. In case of irritability the blow is said to be followed by a brief abduction, with simultaneous dorsal flexion of the foot. Lust believes that this test can further the diagnosis of tetany only in infancy, and has no clinical importance after the third or fourth year.

TONGUE TEST.—The tongue test (Zungenphänomen; Schultze) failed to elicit any response in our case, yet Schultze reports that in all cases of tetany in adults he was able to demonstrate a peculiar mechanical hyperirritability of the tongue, a slight blow upon the tongue producing a contraction with the appearance of deep depressions.

Course of Tetany.—The course of tetany following thyroidectomy has been divided by Frankl-Hochwart into 3 classes: first, cases characterized by onset soon after operation, with severe course and fatal outcome; second, cases in which the symptoms appear soon after the operation but subside after a variable time and are followed by recovery; third, cases in which the patients live but with symptoms of tetany with which may be associated in variable degree evidences of myxedema. It is evident, therefore, that the course of tetany is uncertain.

Treatment.—Medical treatment consisting of the administration of calcium lactate and parathyroid nucleoproteid, should be tried at the first appearance of symptoms of tetany. The symptoms usually can be controlled by these measures, at least temporarily during their administration.

The specific indications for parathyroid transplantation are:

1. When medical treatment seems of little or no avail.
2. When symptoms are severe and are growing progressively worse or are unchanged after a period of a week or ten days.
3. When symptoms of a milder grade persist for a sufficient period to make it improbable that spontaneous cure will take place.

GENERAL PRINCIPLES OF TISSUE TRANSPLANTATION.—Parenchymatous tissue seems to have been successfully transplanted in animals of the same species, and between human beings. But the transplantation from animal to man, as between animals of different species, has uniformly failed.

Recent experiments appear to suggest the possibility of organ transplantation in entirety with reëstablishment of the circulation by vessel suture, but this modification has not been sufficiently developed for practical application (Stich; Heller).

TECHNIC OF PARATHYROID TRANSPLANTATION.—Various sites for implantation have been recommended, such as the subcutaneous tissues, properitoneal tissue, omentum, spleen, and bone marrow. In determining the site, attention must be given to the freedom from serious danger which it offers and to its qualifications for supporting the life of the implanted tissue, namely, high vascularity and richness in lymphatics. The properitoneal tissue or bone marrow should be elected as sites favorable for a "take" and as the ones which expose the patient to the least danger.

A parathyroid is carefully sought in a bloodless field, dissected out, and removed in the course of a goiter operation in an otherwise healthy young patient; but fair assurance must be felt from the nature of the goiter that the loss of one parathyroid will not subsequently be prejudicial to this patient. The organ is put immediately into Locke's solution [1] and kept at body temperature until implanted, or, better, the implantation is made immediately after removal.

The patient is anesthetized by the drop ether method and a properitoneal bloodless pocket made beneath the rectus abdominis. Local anesthesia is not to be recommended because the infiltration of the tissues may be prejudicial to a "take." Our experience in Case II was unfavorable to nitrous oxid anesthesia. The parathyroid is split without removing it from the solution and laid well open, or it is cut so as to expose 2 or more raw surfaces; the technic differs in this respect according to the size of the gland. The implant is then placed in the pocket prepared for it with a minimum of manipulation and exposure to the air. After complete hemostasis the wound is closed without drainage.

In Case I, I utilized grafts taken from accident cases. They were removed under aseptic precautions from 3 cases immediately after death. They were put at once into ascitic fluid and implanted as soon as possible in the subcutaneous tissues. All the wounds healed by primary union. While this procedure may be adopted in cases of necessity, where a graft cannot be obtained from a living subject, its effectiveness has not been sufficiently demonstrated to make it the method of choice. Transplantations from animal to man should never be attempted.

RESULTS.—So few parathyroid transplantations have been made in man that, even if the symptoms of tetany disappear after an implantation has been

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[1] Locke's solution:

Sodium chlorid	0.9	gm.
Potassium chlorid	0.042	gm.
Calcium chlorid	0.024	gm.
Sodium bicarbonate	0.03	gm.
Dextrose	0.1	gm.
Distilled water	100	c. c.

made, the value of the graft is still conjectural; only its removal (functional test), which is not justifiable, could demonstrate the real effect of the transplantation. Three interpretations are possible if the symptoms subside after parathyroid transplantation. First, that the graft exerted no influence. It is possible that the tetany was destined to be self-limited and that the parathyroid implantation happened to precede by a short time the disappearance of the symptoms. Among the reported cases of tetany are some in which the symptoms appeared soon after the operation and subsided after a variable time with complete recovery. Second, that the graft may have exerted a temporary effect during its absorption in tiding over a transitory tetany while the injured or devascularized parathyroids were rehabilitating themselves. Leischner inclines toward this view. Third, it is possible that the transplanted parathyroid is permanently effective as a functionating graft. Without entering into an extensive consideration of tissue transplantation, it may be asserted that the parathyroid is a relatively favorable tissue for grafting. Halsted's experiments on dogs indicate that a small autograft, if a considerable deficiency in parathyroid tissue has been created, is capable of living and preventing tetany. This he proved by the "functional" test.

In view of the uncertain status of all proposed methods of treatment, the importance of prophylaxis is evident.

TRANSPLANTATION OF THE THYROID

Of all parenchymatous transplantations, that of the thyroid gland has received the most attention. The original experimental transplantations of this organ in animals were done by Schiff; the first attempt in man was made by Kocher in a case of cachexia strumipriva (1883). The functional results in both instances were transitory only. It was tried by Bircher and others for myxedema, with similar results. The first attempts which seem to have been successful in respect to the life and function of the transplanted thyroid tissue were those of v. Eiselsberg and Cristiani. Payr has reported striking and suggestive results in animals and in the human subject. He transplanted with considerable benefit a large piece of thyroid tissue from a mother into the spleen of her child who was suffering from congenital myxedema.

Kocher obtained some success by implantations into the medulla of the tibia. His technic is as follows: The diaphysis close to the epiphyseal line is elected on account of its vascularity. A bone-periosteal flap is lifted and a pocket is made in the medulla. A silver ball about 1 cm. in diameter is inserted and the bone flap and skin are closed over it. After a few days granulation tissue has formed around the ball and the wound is reopened, the ball removed, the wound washed with salt solution, and the implant, as nearly as possible the size of the ball, is inserted into the bloodless pocket. Normal or hyperplastic thyroid tissue from which the capsule has been removed should be used.

The conditions in which thyroid transplantation may be considered are cretinism and cachexia strumipriva.

1. **Cretinism.**—Congenital absence of functionating thyroid, evidences of which are usually delayed for some months after birth, results in peculiar characteristics which are too well known to call for enumeration here. Persistent thyroid feeding replaces to some extent the thyroid deficiency and improves the condition of the patient.

Operative treatment through thyroid implantation has been recommended and carried out by Payr with somewhat encouraging results; but organ transplantation has not been placed on a practical basis sufficiently firm to warrant much hope of cure in this class of patients who are congenitally so deficient. However, the hopeless condition of the patient makes the effort justifiable.

2. **Cachexia Strumipriva.**—The facility with which patients can be rendered immune to the ill effects of postoperative thyroid deficiency by thyroid feeding, the likelihood of the symptoms being transitory through hypertrophy of the remaining tissue, and the uncertainty of the efficiency of transplantation render the indications for thyroid implantation in this type of case extremely rare. Certainly no procedure of a serious character, such as organ transplantation with vascular anastomosis, is advisable. Yet implantation of thyroid tissue is warranted when thyroid feeding is impracticable or unsatisfactory.

The technical details of tissue transplantation have been discussed sufficiently. The properitoneal tissue or the medulla of the tibia or both are the sites to be used for implantation.

LESIONS OF THE PARATHYROIDS

Lesions of the parathyroids are rarely recognized. Those which demand surgical intervention, namely, cysts and benign tumors, are too unusual to admit of any specific operative plan. The general principles laid down for operations on the thyroid may safely be applied.

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CHAPTER VIII

THE LARYNX, TRACHEA AND BRONCHI

Nathan W. Green

EPIGLOTTIDECTOMY

(Removal of the Epiglottis)

Indications.—In certain conditions of the larynx, where the tumefaction and consequent immobilization of the epiglottis cause it to act as an obstructing body in the pharynx, either hindering deglutition, embarrassing respiration, or standing in the way of proper inspection and treatment of the interior of the larynx, the epiglottis may be removed through the mouth, either by means of direct vision or with the aid of the laryngeal mirror.

The pathological thickening may be caused by one form or another of tuberculous infiltration (Lake, 31; Chambers, 9), or by the extension of a carcinomatous process which would be of the extrinsic type of laryngeal carcinoma, which, according to Baratoux (2), often originates in the epiglottis. (This has, however, not been the experience of some of our New York laryngologists—Delavan, 14.)

The operation is sometimes performed as a palliative procedure to aid in swallowing and to relieve the obstruction to breathing. A cure of the condition has been reported in one or 2 instances, but when reported the time elapsed was not long after the operation (Baratoux, 2).

An abscess or cyst of the epiglottis may require intervention, and in either of these cases a partial or complete epiglottidectomy may be done. F. F. Chamberlain (8) reported a cure of an infected cyst of the epiglottis by means of cutting away the anterior wall with laryngeal scissors.

Technic.—The operation of epiglottidectomy may best be described in the language of T. R. Chambers. General or local anesthesia may be used. Chambers (9) describes the operation as follows:

> "A so-called Brandigee adenoid forceps, having three cutting edges, was successfully employed. With the first finger of the left hand as a guide, the cutting jaws of the forceps were engaged about the tumor and epiglottis. The anterior jaw was pushed well down toward the neck of the epiglottis. With one closure of the

handles the epiglottis and its tumor were severed and adrenalin was swabbed into the wound. There was quite some bleeding, which, however, was soon controlled."

Results.—In the case of the patient of Dr. Chambers, no disagreeable after-effects were noted, and she had "not a single cough nor choking spell when swallowing food." Five months after the operation some swellings which recurred had disappeared, and the view of the vocal cords was clear and distinct.

REMOVAL OF NEW GROWTHS OF THE VOCAL CORDS

Operations on the vocal cords are done by means of direct vision through the mouth, the indications being benign growths, such as papillomata and fibromata, singers' nodules, and cysts (23). These last are best removed by the galvanocautery. C. J. Koenig, of Paris (29), makes use of a specially designed cautery and obtains good results. Very little reaction of the cords follows operation (two or three days at the most).

Use of the Galvanocautery and Forceps.—E. Hautière, in his Paris thesis, 1901, says that the only rational treatment, to his mind, is the surgical treatment. It comprises destruction by means of the galvanocautery or removal with forceps.

> "The galvanocautery, which is employed most frequently, is the one which Botey has recommended and which has been adopted by M. Lermoyez in France. It consists of a very fine point which is slightly curved. It is sufficient to bury the point in the nodule from one to two millimeters, but one can easily conceive that he could miss the nodule and burn the neighboring part of the vocal cord. Furthermore, if the nodule is not completely destroyed, it is possible that the process will recur and a new swelling will form. Much more surgical and radical is the extirpation of the nodule by means of forceps. Botey has had constructed for this purpose special forceps with cutting edges taking away the tumor, as with punch forceps. It is this method which seems preferable to me."

This procedure is done at one sitting, under a local anesthetic, and the after-treatment comprises a spray to the larynx and resting the voice for several days.

In cases of papillomatous thickening of the vocal cords, it may be possible to operate through the direct vision speculum, placing the patient in a chair with his chest forward and the head thrown back somewhat, but not so far as to curve the cervical vertebræ backward. Anesthetize the pharynx and larynx by swabbing and a cocain spray of a 10 per cent. strength, or with a strong solution of novocain. When the anesthesia is established, after a period of 15 to 20 minutes the direct vision laryngoscope of the Chevalier Jackson type is introduced in the upper portion of the larynx and inspection made with the aid of an electric light. Any fibroma or papillomatous growth may then either be pinched off with forceps or taken away by means of a snare.

The after-treatment of this condition consists in applications of a weak formalin solution to the cords, and sparing the voice as much as possible, talking only in whispers for the first week subsequent to the procedure.

Other Methods.—If this method does not rid the patient of his trouble, then resource must be had to a thyrotomy or subhyoid pharyngotomy, or even a tracheotomy. Abbe (1) has recorded cases of cure of these persistent papillomata by means of radium—50 milligrams of radium bromid placed within the rima glottidis and held there for 20 to 30 minutes.

In some patients who are unable to extend the neck sufficiently to give a satisfactory view of the interior of the upper portion of the larynx, especially the anterior commissure, the papillomatous growth may be removed by means of indirect vision—that is, by the aid of the laryngeal mirror and a snare curved so as to go directly into the larynx while the patient sits upright.

LARYNGOTOMY BY MEANS OF A CUTTING DILATOR

Whistler (38) reports 2 cases of syphilitic stricture with an account of 2 cases operated upon by means of a new cutting dilator. The instrument which he devised combined the properties of a knife and a dilator in one. The dilator was almond-shaped, 14 mm. anteroposteriorly, and 8 mm. in thickness, with a concealed knife which could cut either anteriorly or posteriorly.

In one case the stricture was caused by adhesions of the ventricular bands anteriorly. After a tracheotomy for urgent dyspnea, the operation consisted in pushing the dilator down until it fitted tightly in the stricture and then protruding the knife. "After a gentle movement of the handle upward and downward," he "felt the resisting point in the larynx yield and pressed the dilator easily into the glottis." This "linear incision could be plainly seen when the stricture had been divided." On repeated occasions the dilator was again introduced, but without the knife, to follow up the advantage gained.

In a second case Whistler passed the laryngotome between the vocal cords and divided the stricture between them. The dilator was then introduced once a day for a month.

Both patients wore a tracheal cannula for many months after the operation on the stricture.

LARYNGOSTOMY

Indications.—It is J. Guisez (22) who says that Killian and Piniaseck, in Germany, and Sargnon, in France, were the first (1906) to practice this operation, which is destined to cure patients with fibrous stricture of the larynx, and permit those who otherwise would be condemned to it forever to escape from the cannula.[1] Laryngostomy may also be performed in perichondritis of the larynx (Iwanoff and Kravitz, 24).

Technic.—The intervention comprises the following steps:

> "(a) The thyroid and cricoid cartilages are split by means of scissors and the incision is prolonged to the level of the tracheal opening where the cannula is situated. (b) The split cartilaginous edges are then sutured to the skin edges of the wound by means of silk thread. (c) The cicatricial tissue is then removed by means of a bistoury as widely as possible from the larynx thus opened. (d) A soft rubber tube is introduced into the wound with a silk thread fastened at one extremity to prevent its going into the trachea or pharynx, and the larynx is packed with aseptic gauze. (e) The presence of the tube takes away the slough from the remainder of the neighboring fibrous tissue, increases the degree of permeability of the larynx and skims over the interior surface of the larynx.
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> "One can increase progressively the volume of the drain and give to the larynx a sufficient caliber. Dressings and the drain should be changed almost every day during the several months (8 to 15 months) and when one is well assured that the respiration goes on in the normal fashion and regularly, the external laryngeal orifice can be closed by an autoplastic operation. Such is the principle of this operation which requires, as one can see, the greatest patience, but which has already given the best results."

If this procedure is done in the case of a child, care must be exercised in selecting the size of the soft rubber drain. In this case it should be 4 to 6 cm. long and of a size from No. 15 to 20 F. It should be tied into the wound with silk and at the upper end it should not pass above the level of the arytenoids (J. Baratoux, 2a).

THYROTOMY

By the term thyrotomy is meant the opening of the laryngeal box through the thyroid cartilage and, preferably, in the middle line. This procedure has also been called laryngofissure.

Indications.—In papillomatous growths which exhibit a tendency to recur after surgical intervention, opening of the thyroid cartilage and removal of the growth by curetting through this opening may be indicated.

Solis-Cohen (36) says, however: "It is extremely liable to impair the voice irretrievably. . . . For this reason it may be questionable in certain cases, especially in children, when the growth is in the upper portion of the larynx, whether the more conservative operation of subhyoid pharyngotomy should not be performed in preference."

In small intrinsic epitheliomata of the larynx which have shown less malignant tendency, the opening of the thyroid cartilage, with the removal of the growth and the mucous membrane surrounding it and some of the cartilage beneath it, has effected a cure. This procedure has been recommended by some authors of wide repute. St. Clair Thompson (37), in 1912, reported operations on 10 cases of intrinsic cancer of the larynx by laryngofissure, with a lasting cure in 80 per cent. Butlin (7), on the other hand, in 1908, put himself on record as being more inclined to laryngectomy.

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[1] Guisez says, however, in a footnote, that for several months he has been undertaking a circular electrolytic dilatation of the cicatricial strictures of the larynx, relieving many patients of their cannulæ by this very simple proceeding.

Thyrotomy may be the only alternative that a patient will allow the operator, and in this case it should only be undertaken with the full knowledge on the part of the patient that it is not the safest procedure as far as prevention of a recurrence is concerned. Chiari maintains that a radical cure of these growths, no matter how small, cannot be effected by means of an incomplete laryngectomy, much less a thyrotomy with removal of only part of the underlying thyroid cartilage; and in short, as in cancer in any other part of the body, such a limited procedure as removal of part of the offending organ seems unsurgical and only courts disaster later in the shape of a recurrence.

Large foreign bodies lodging in the larynx may be removed by thyrotomy, but on account of the tendency to the consequent agglutination of the anterior portions of the vocal bands in healing, this sectioning of the thyroid cartilage is to be avoided if other means are sufficient to give access to the interior of the larynx.

Technic.—An incision is made from the hyoid bone to the cricoid cartilage in the middle line of the neck, passing everywhere down to the cartilage. The thyroid cartilage is then split accurately in the middle line, either with a sharp knife or, as some recommend, with straight scissors, the blade entering at a point between the thyroid and cricoid cartilages and including the mucous membrane, together with the thyroid cartilage. The division is extended up directly between the anterior extremities of the vocal cords. Great care must be maintained in keeping to the middle line, as otherwise one or the other of the cords may be injured and the return of the vocal function will be much impaired.

When the thyroid cartilage and the mucosa have been opened, the assistant retracts on either side with sharp retractors and in this way throws the interior of the larynx open to view. If a papillomatous condition is now seen on the cords, it may be removed with scissors, touching the base with a weak formalin solution. If the growth is situated between the true and the false cords—that is, in the ventricle of the larynx—and if it gives evidence of malignancy, it may be found necessary to remove one cord in order that a sufficiently wide margin of removal may be effected. The growth should then be taken out without disturbing it and a piece of the thyroid cartilage underneath it should be removed, in order that no cancerous elements may be left at the base. A careful study must then be made of the lymphatics leading from the larynx and the ones receiving the drainage from the site of the new growth should be removed if there is any sign of enlargement of the nodes.

The 2 halves of the thyroid cartilage are now approximated and held together with small silver wire sutures, but these should not penetrate the mucosa.

Healing of the cartilage will probably not occur, but, what amounts to the same thing, healing by connective tissue, will better occur if the sutures are not absorbed too early, if at all. As in other wounds of the air passages outside of the chest, it is well to insert a temporary drain, upon suturing the skin, to avoid the unpleasant complication of a subcutaneous emphysema.

In cases where the consequent edema of the larynx may seem inevitable, it is wiser to do an associated tracheotomy and, after the thyroid cartilage is closed and the laryngeal portion of the operation is finished, leave a tracheotomy tube in place for 4 days, until the time for the edema to occur has passed.

LARYNGOTOMY THROUGH THE CRICOTHYROID MEMBRANE

Indications.—The indications for this procedure are obstruction to the glottis from any cause; the presence of papillomatous growths in the larynx; or the presence of foreign bodies in the larynx, which cannot be extracted through the mouth. It is not the operation of choice in opening the air passages, but is recommended in emergencies and is far better than cutting through the cricoid cartilage. It may be quickly done and without special instruments.

The object of selecting this site for the laryngeal opening is to avoid injury to the thyroid cartilage above, which may later cause an impairment to the voice from cicatricial joining of the anterior extremities of the vocal bands upon healing; and below to avoid injuries to the cricoid cartilage, which is the main framework of the mechanism of the larynx (J. Solis-Cohen, 36). Injury to this cartilage may cause sloughing of it, so that there may be impairment in its healing, causing a deformity of that portion of the larynx and a constriction of the lower opening, as well as great impairment of the modulation of the voice.

Laryngotomy through the cricothyroid membrane may also be done in children where the operator feels disinclined to cut across the isthmus of the thyroid, which, in these cases, lies at the extreme upper part of the trachea. This gives a very high opening. The isthmus of the thyroid in children is, however, more feared by operators than seems at all necessary. Foulis (16) of Glasgow has called attention to this fact and even gone so far as to recommend that the point of election for the opening of the air passages lies directly behind the isthmus of the thyroid in cases of emergency. He makes a practice of cutting right through the isthmus, not fearing the hemorrhage which is slight and can be controlled by clamping between two hemostats.

Edema of the larynx calls for a laryngotomy when efforts at scarification have failed to reduce the swelling. This is well done through the cricothyroid membrane. It is a comparatively harmless procedure, and the subsequent impairment of the workings of the larynx is very slight. In the hands of a surgeon who does not feel himself competent in laryngeal technic, it is better to open the air passages in cases of foreign bodies in the larynx, and to remove the foreign substance by the external route, rather than to attempt to extract it by direct vision through the laryngoscope. A laryngotomy through the cricothyroid membrane is here indicated.

It is also indicated in diphtheria where intubation cannot be successfully done, or where intubation has been done and no relief obtained. In the hands of many, it may be better to do a laryngotomy rather than to waste time and to use up the strength of the patient by atempting to do, what is to them, the unfamiliar procedure of intubation.

Technic.—The procedure is a comparatively simple one. It is generally the preference of the operator to stand on the patient's right and to grasp the larynx, made prominent by the extended head, with the thumb and forefinger of the left hand. The incision is then made in a longitudinal direction over the cricoid and thyroid cartilages in the middle line. (In all proceedings care should be taken to make the skin incision as long as the wound in the trachea and larynx. Failure to do this may result in a very embarrassing subcutaneous emphysema or in a prolonged infection, which threatens the patient's life by the presence of septic wound secretions.)

The sternohyoid and sternothyroid muscles should be quickly retracted from the middle line when the cricothyroid membrane is exposed. This may be entered by plunging the scalpel directly backward, either in a longitudinal or in a crosswise direction, taking care not to injure the back of the larynx. All bleeding should be stopped before the larynx is entered. In order to avoid some embarrassment caused by injuring the isthmus of the thyroid, it is well that care should be taken in the case of children to push it out of the way, that is, downward. When the cricothyroid membrane is finally open, either a soft rubber tube should be inserted, just filling the opening, or a curved trachea tube, or if these are not available, a piece of bent wire may be found serviceable to keep the wound open. If the tube or the tracheal cannula is used, it should be changed at first at intervals of 12 hours or even oftener, to prevent pressure necrosis at the back of the trachea. The wound should be dressed with moist dressings and the dressings should be changed several times a day. In short, the wound should be treated as one having abundant secretions which will run into the trachea if vigilance is not exerted.

There is a general feeling of fear on the part of patients against entering the structures of the neck with any cutting operation. This fear is also harbored to a large degree by many physicians. It seems to me that if this popular fear could be removed by education, physicians would more frequently be willing to enter the air tube when the emergency was arising, rather than to waste valuable time in trying to meet the emergency by measures with which they are not at all familiar, but which in the popular mind are thought to be less formidable. I would advocate that more attention be paid to this simple procedure for relieving the symptoms of rapid asphyxia, so that less hesitation should be entertained with regard to performing it, and less time lost during the critical moments when dyspnea is becoming more and more serious.

PARTIAL LARYNGECTOMY

Indications.—The indications for a partial laryngectomy overlap those for a thyrotomy. It is performed for new growths of the larynx. Krishaber (30) has classified laryngeal cancer into intrinsic and extrinsic growths. This procedure is especially indicated in small intrinsic growths of the larynx. D. Bryson Delevan noted that in small epitheliomata of various parts of the body, e. g., in the epiglottis and helix of the ear, where the growth is situated upon hyaline cartilage, a removal of the growth, together with the subjacent cartilage, effects a cure, and it has been noted that early involvement of the lymphatics does not occur. This "suggests an important deduction with regard to intrinsic carcinoma of the larynx, namely, that in certain localities of the body, early involvement of the lymphatic system does not seem to be a necessary occurrence. . . . In consequence of this, early complete excision of the diseased area may be followed by permanent cure."

Technic.—The operative procedure consists in making an incision from over the hyoid bone to the cricoid cartilage in the middle line, splitting the thyroid cartilage carefully and accurately, opening the mucosa, inspecting the larynx, and taking out that portion of the larynx upon which the new growth is situated. This is a little more severe operation than the preceding and will be found applicable to intrinsic new growths that have progressed further than those that are removed during thyrotomy. It is generally necessary to take out half and leave the other side with its attached vocal cord intact. This, in fact, is the procedure which is commonly associated with the term "partial laryngectomy." As in the case of new growths of the body in any situation, the nodes of the lymphatics draining the affected area should be sought for and, if involved, they should be carefully and thoroughly removed, making a wide dissection. This may be done at a later sitting, but it should never be neglected nor delayed for more than 2 weeks. The lymphatic drainage from the larynx is first outward toward the bifurcation of the common carotid and, secondly, downward in the median line. Fairly extensive intrinsic growths, however, have been observed without any apparent enlargement of the neighboring lymph-nodes.

Botey (3) recommends that, if partial laryngectomy be done for cancer, the laryngeal stoma may be kept open for a year or two without inconvenience, in order to observe the progress of healing.

COMPLETE LARYNGECTOMY

Baratoux (2) gives Billroth the credit of having, in 1873, performed the first complete laryngectomy for cancer.

Indications.—For a complete laryngectomy there is but one indication, i. e.

cancer of the larynx. In the term cancer is included any form of malignant growth. The vigor of the patient and the extent of the growth will modify even this indication. The operation of removal of the larynx is mutilating in the extreme and in the past has been accompanied with a high mortality. Latterly, in the hands of the more skillful surgeons and especially the general surgeons who have had a laryngeal training, the mortality has been reduced.

To encourage one in entering upon so grave a field, let us refer to the following statement of Chiari (10), who says that the surgeon is obliged to undertake serious operations if there is merely a prospect for radical cure. "The results of extirpation of cancer of the larynx are, as a rule, better than in cancer in other parts of the body."

> "The intrinsic cancer generally affects the vocal band and in this way causes hoarseness, which induces the patient to consult a laryngologist. More uncommonly it is located in the ventricular bands, in the ventricle, or below the glottis; in any event it has the special characteristic of not infecting the lymph nodes of the vicinity in the earlier stages and even late in the disease."

This property of the cancer, of being held within the cartilaginous box of the larynx, has also been noted a number of years ago by Delavan and is now common knowledge with those surgeons at all familiar with the disease and its operative treatment. The operation for cancer of the larynx must be conceded to the experienced surgeon. He must place his knowledge "at the service of laryngology." (Gluck.)

Chiari (10) further states that "radical cure can practically not be obtained by intralaryngeal operations. Therefore for more than twenty years I have held the opinion that as soon as any growth in the larynx has been determined to be cancer, it must be operated upon externally, if the operation is still admissible"—that is, by a total laryngectomy.

Chiari also says, according to Navratil: "The common squamous-cell carcinoma may be entirely removed by thryotomy when it is intrinsic and when it does not interfere with the mobility of the vocal band."

"He advises," says Navratil, "partial extirpation in simple, intrinsic squamous-cell carcinoma, involving only ½ of the larynx or the epiglottis, which has caused no metastasis. He advises total extirpation in the beginning stages of horny, squamous-cell cancer and in squamous-cell cancer which has extended, if the lymph-nodes are felt small and not fixed."

The extent of the intrinsic cancer governs its operability to a large degree. Navratil (33) further says: "Total extirpation is not indicated in extensive intrinsic cancer with participation of the esophagus and in horny, squamous-cell-cancer, except when no lymph-nodes are present, and naturally not in the very old."

Gluck, on the other hand, has obtained striking results in the removal of extensive intrinsic cancer with extirpation of part of the esophagus.

It seems to me that in this combined condition, the extent of the growth, the absence of palpable lymphatic involvement, the microscopical character of the growth, and the speed and skill of the operator, together with his familiarity with these conditions, both in the living subject and on the cadaver, should determine whether the patient should be submitted to surgical interference or not.

Butlin (7) gives a report on 37 cases of cancer of the larynx on whom he had operated by 31 thyrotomies, 2 hemi-laryngectomies and 7 total laryngectomies (some had 2 operations), 15 of whom were well after 3 years. In the end of his paper he says regarding laryngectomy:

> "I began to perform the operation on account of Gluck's success, and of the excellent modification due to Solis-Cohen. I wish I had begun to perform it earlier, I am sure that several of the cases on which I performed thyrotomy were much better fitted for laryngectomy and I cannot help thinking that I might have saved one or two of the patients in whom recurrence took place if I had then removed the larynx."

The new growths which are termed cancers and which indicate the removal of the larynx are either epitheliomatous or sarcomatous—very rarely endotheliomatous (Chevalier Jackson, 25). Of the epitheliomatous growths, some may be situated entirely within the larynx, and these are classified by Krishaber as intrinsic growths. Some may be situated in the pyriform fossa in the upper pharynx and encroach upon the larynx, and these are classified by him as extrinsic growths. When the intrinsic growth has grown sufficiently to involve the mucous membrane outside the larynx, then that must also be classified as extrinsic. The extrinsic growth is situated without the larynx and either encroaches upon the larynx from without or it is situated entirely on the upper aspect of the larynx. In 212 cases seen by Sir Felix Semon the cancer was intrinsic in 136 and extrinsic or mixed in 76 (St. Clair Thompson, 37). In 141 cases of cancer of the larynx seen by Chevalier Jackson (25) in 23 years (1866 to 1909) 98 were intrinsic and 43 extrinsic by origin or extension.

Sarcoma of the larynx is a rare condition and the site of it is generally upon one of the cords or vocal bands, and necessitates removal of the larynx. If the upper part of the esophagus is the site of the epitheliomatous or carcinomatous growth and if the growth has also invaded the laryngeal structure, the larynx, together with the upper part of the esophagus, may have to be removed. This is a much wider procedure than laryngectomy alone and requires that the operation of laryngectomy be supplemented by partial esophagectomy. These cases are, however, of such comparatively rare occurrence that no rule of operation can be laid down for them, as they occur only as individual cases in the course of one's surgical experience. It is safe, however, to follow anatomical lines when interfering with such a pathological condition.

Diagnosis of Laryngeal Cancer.—Before discussing the severe and radical procedure of laryngectomy, it may be well to look into the means of establishing a diagnosis of the new growths of the larynx. It is not our province to go into the symptomatology of carcinoma of the larynx here, but it is timely to state in passing that continued hoarseness of the voice is one of the first symptoms of cancer of the larynx and should lead to a thorough examination. The extrinsic growths may be seen by means of the laryngoscopic mirror and this should first be tried. The typical appearance of an epithelioma involving the mucous membrane may at once make one reasonably certain of the condition. This inspection can easily be done with a slight cocainization of the pharynx and seems to be the first step taken toward determining the true nature of the disorder. If the growth has not progressed far or if the symptoms pointing to trouble in the laryngeal or pharyngeal region have not lasted long, it is possible for the patient to extend his head to such a degree that the region may be inspected by the direct vision laryngoscope, or through a short esophagoscope. Here, by means of an electric light, one can see the epitheliomatous growth and if doubt still exists as to the true nature of it, a piece may be removed by means of a punch forceps and subjected to microscopical examination.

It is the usual and very good rule not to interfere with a new growth before its complete extirpation is planned. In other parts of the body, partial removal or interference with malignant tumors has been known to set up increased activity of the growth. It is, therefore, well not to attempt to secure a specimen for microscopical examination until plans are completed to remove the growth if it be malignant. The operation of laryngectomy is so disabling a procedure that it seems to me that the patient should not be subjected to this ordeal without having first exhausted all means of confirming the diagnosis, even at the risk of starting up of the growth. It is neither fair to the patient nor to the operating surgeon to leave this undone when it is possible to do it. In this opinion Chiari coincides. He says:

> "It is certainly indispensable, in most of the cases, to make a positive diagnosis. It is difficult indeed to recognize an intrinsic cancer in the beginning by laryngoscopy alone. Many laryngologists and especially in America, Thrasher and Simpson in 1900, and Lincoln in 1903, have given expression to this view. It is, therefore, quite natural to remove a piece of the neoplasm intralaryngeally and to have it examined microscopically by a competent pathologist. This slight operation does the patient no harm.
>
> "Mackenzie's position—'The removal of the piece for microscopic examination too often means the beginning of the end'—is certainly incorrect. Many operators, including myself, have never seen such a result. . . Still I do not wish to deny that any incomplete removal of a carcinoma may increase its growth."

Lupus of the larynx or simple necrosis may stimulate cancer (Krishaber, 30).

In intrinsic growths of the larynx, the tumor is rarely situated below the true vocal cords. It may, however, originate in the true cords. Where it is small and below the true vocal bands, it may be passed unnoticed until finally it causes irritation to the cords, hoarseness, and constant cough. Where it is situated below the true cord, it is difficult to find, and the only thing which may lead our attention to the growth in this situation is a congestion and slight reddening of the cord that is situated above it.

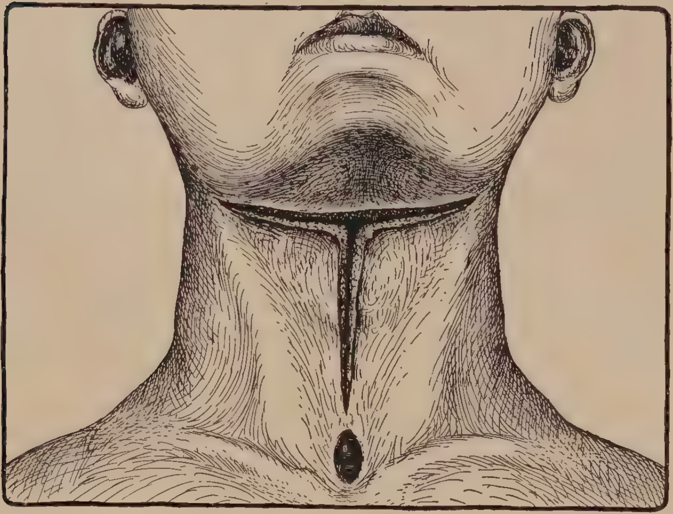

FIG. 1.—COMPLETE LARYNGECTOMY, PRELIMINARY TRACHEOTOMY, AND SKIN INCISION FOR BEGINNING SECOND STAGE OF OPERATION. (From original dissections.)

A one-sided edema of the arytenoid region may occur in intrinsic growths that have progressed further. In the more advanced cases of cancer of the larynx one must look for lymphatic involvement, but even in well-advanced intrinsic growths it may be impossible to find it by a gross examination. In the extrinsic growths this involvement takes place much earlier, first on the side in which the growth is situated. This earlier involvement is one great reason why operations on extrinsic growths are followed by a much greater percentage of recurrences than those of the intrinsic variety. The lymphatic involvement in the extrinsic variety is felt along the anterior border of the sternomastoid muscle opposite the upper border of the thyroid cartilage, and extends downward according to the amount of invasion. In the intrinsic growths, the lymph-nodes first involved may be found at the base of the neck. Fairly extensive intrinsic growths may exhibit no lymphatic involvement.

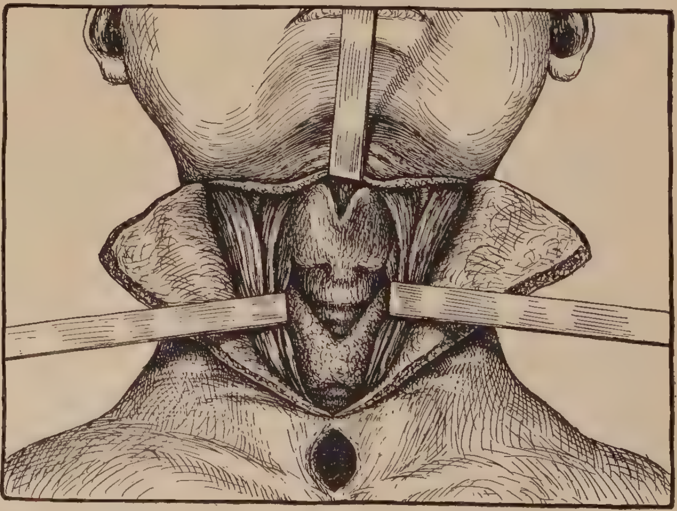

FIG. 2.—COMPLETE LARYNGECTOMY, EXPOSURE OF THYROID CARTILAGE, TRACHEA AND THYROID GLAND. The retractors are drawing aside the sternohyoid and sternothyroid muscles.

Technic.—The operation of complete laryngectomy may be done either at 1 sitting, as is advocated by Gluck (17), or in 2 sittings, as is advocated by Crile.

SINGLE-STAGE OPERATION.—Gluck says:

> "In the great majority of cases where a simple or complicated laryngectomy is in question, I isolate the pathological condition by tunneling the tissues by means of Kocher sounds and by ligaturing the vessels. After it has been freed in this manner, I take out the tumor en bloc and do not practice section of the trachea until the end of the operation, taking pains to place threads on its inferior (proximal) end, which permits it to be drawn up and sutured to the skin. [He sutures it into a buttonhole of the skin.] I place between the operative wound and the air passages a perfectly stanch barrier of living tissues."

TWO-STAGE OPERATION.—The operation may be preceded by a tracheotomy or even a gastrostomy for feeding, as was suggested by Thiersch for pharyngotomy, and advocated by de Quervain independently for the same condition in 1899, and later for laryngectomy (15). Chevalier Jackson (25) placed himself on record as favoring a gastrostomy prior to every laryngectomy in 1909. He insists upon it if the esophagus is involved.

However, each has claimed a large percentage of recoveries by his particular method. The individual cases may present such variations as to suggest one form or other of the procedure in order to meet certain conditions. If dyspnea be a prominent symptom when the patient first presents himself, a procedure involving a preliminary tracheotomy is advisable. If the patient is robust and in comparatively good condition, the whole thing may be done at one sitting. The advantages claimed for the preliminary tracheotomy are: an acquired immunity to tracheal and bronchial infection, the anchoring of the trachea in the tissues of the neck before it is completely cut across, the forming of a barrier against mediastinal infection

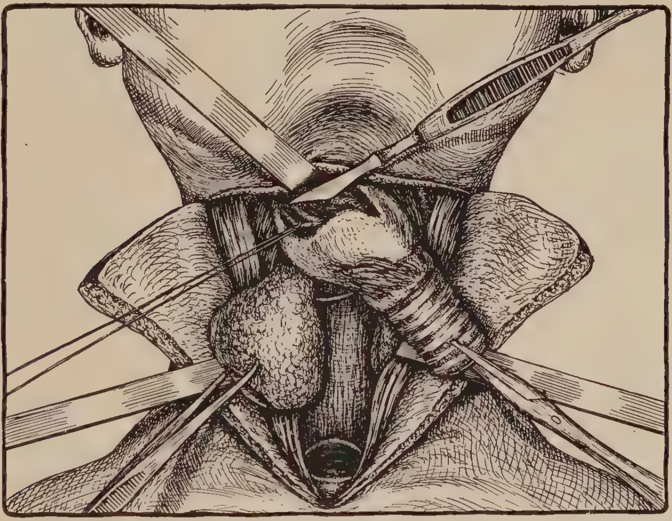

FIG. 3.—COMPLETE LARYNGECTOMY. INCISION OF SECOND STAGE INVADING TRACHEOTOMY WOUND AT ITS UPPER BORDER. The trachea is severed without detaching the anchored portion in the lower angle of the tracheotomy wound. The thyroid gland is divided and drawn outward. The larynx with the upper 2 or 3 rings of the trachea is now drawn forward and to one side showing the recurrent laryngeal nerve and the superior laryngeal nerve. (This latter is injected with a novocain solution before cutting it.)

by granulation tissue, the separating of the tissues on one side from the vagus nerve, thereby passing the storm of vagus irritation of that side, and the division of an otherwise extensive operation into 2 parts. The preliminary tracheotomy if possible should be done 8 to 10 days before the larynx is to be removed. Delavan (13) says: "While early tracheotomy is not advised by some of the ablest general surgeons of the day, it is certainly right in principle and according to the best light of experience correct in fact." It should be accompanied by the dissection of the planes of the neck well down so that the vagus nerve of that side and its attack of irritation may be passed. The other side is approached at the next operation. Crile calls attention to the undesirability of disturbing both nerves at the same time, as a double infection of the vagus nerves is a very serious complication and may prove fatal, due to its influence upon the heart action.

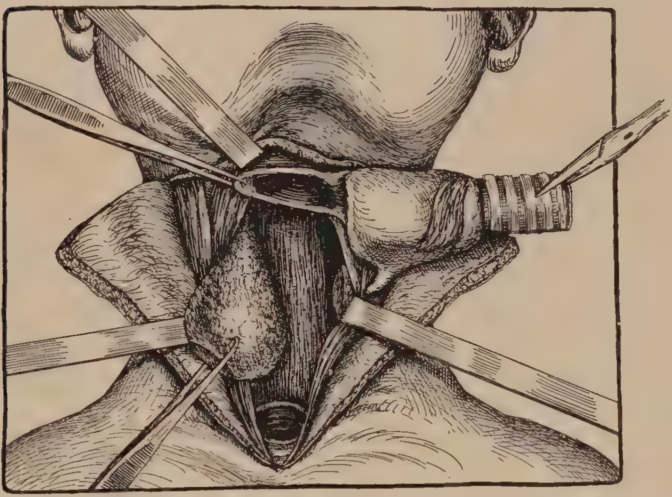

Fig. 4.—Complete Laryngectomy. This Picture Shows the Pharynx Opened in the Final Step of the Removal of the Larynx.

If the operation be done in two stages—and I am inclined to favor such a course—one cannot do better than quote from Crile (11). Under the consideration of the special difficulties and dangers to be overcome during the procedure of laryngectomy, he says:

> "Pneumonia following operation on the upper air passages is due in most cases to one of two causes: (a) the inhalation of blood, and (b) the inhalation of infected wound discharges. These injurious inhalations occur usually in the course of the operation, although occasionally the postoperative oozing is inhaled. They may be prevented in part by scrupulously maintaining a dry field in the entire course of the dissection. . . . The next great danger associated with laryngectomy is that of local infection. . . . The occurrence of some infection must be taken for granted, but it is for us to consider by what means the amount and the virulence of the infection may be diminished and how it can be localized."

(The local infection he tries to combat by previously seeing that there is no infection in the contiguous territories and by careful sharp dissection and immediate closing of the soft parts overlying the wound, and by using the iodoform packing if there must be any wound.)

Mediastinal abscess is another complication, but mediastinitis is probably more frequently the case. Undoubtedly this is favored to a certain degree by the negative pressure of the pleural spaces on either side exerting its influence upon the lymphatic flow and favoring the inroad of infection into this locality.

"If in the course of the laryngectomy, the divided trachea is stitched to the skin, there is great danger that subsequent coughing will cause it to become detached. Its moorings having been lost, it will be thrust back and forth, in and out of the thoracic box, like the piston of an engine. Mediastinal infection will be the almost inevitable result. If, on the other hand, the free end of the trachea is not fixed by sutures, but is held by gauze packing about it, then the trachea will retract within the thoracic cage like the head of a turtle, and again infection will result. It is obvious, then, that the trachea should be so fixed by preliminary operation that there may be produced an invincible barrier of granulations extending across the base of the neck and the entrance to the thoracic cage. There are two methods by which this may be done: the ordinary simple tracheotomy will fix the trachea and will stimulate the formation of efficient granulation tissue; or exposing the trachea and the lower larynx and packing the lateral planes of the neck with iodoform gauze will result in the production of granulations and in fixing the trachea so firmly that coughing cannot break its moorings. Each of these methods by itself alone has certain advantages and disadvantages. The simple tracheotomy is not so certain a safeguard against infection of the mediastinum as is the latter, and it does not result in so firm a fixation of the trachea in the deeper part of the neck, but it has the advantage of establishing a strong defense mechanism in the mucous membrane of the trachea itself. On the other hand, the packing of the deep planes with iodoform, while otherwise an ideal protection, does not supply the protective defenses in the mucous membrane of the trachea. An ideal defense, then, is found in a combination of the two operations, that is, in opening and packing the deep planes of the base of the neck, and at the same séance making a low tracheotomy. By this means the mediastinum is put under strong guard, and at the same time the later technic of the laryngectomy is measurably reduced."

After this preliminary operation has been completed, in which the trachea has been opened and the planes of the neck have been packed off with iodoform gauze, a period of 8 to 10 days is allowed to elapse before proceeding to the main part of the operative technic. The operative technic proper may be carried out under local anesthesia throughout, or, what is better, a combination of local and general anesthesia, as has been the custom for years with Kocher in his goiter cases. For the local anesthesia the usual rules of applying the anesthetic are followed.

"The tissues are divided down to the box of the larynx, the divisions of the platysma and of the other soft parts being preceded also by novocain infiltration. The dissection is then carried down along the lateral aspects of the larynx until the larynx is completely freed. If there is lack of free working space at the upper end, a lateral incision is made parallel with the hyoid. The thyrohyoid muscles above and the sternothyroid muscles below are severed. So far as its muscular attachments are concerned, the larynx is now completely mobilized. If the laryngoscopic examination has fixed accurately the limits of the neoplasm, the level of the division of the larynx may be predetermined, and the next step will be the division of the trachea or the cricoid at a level free from disease. Before this last division is made, however, novocain is infiltrated into the mucosa throughout the entire length of the proposed division. By this means, the terminals of the superior laryngeal nerves are completely blocked and the mucosa may be divided and the larynx opened without causing a change in the respiration or the circulation. If the patient is old and the cartilage is ossified, it is necessary to exert the greatest precaution in dividing the larynx in order that the esophagus may not be injured. The divided end of the larynx is next

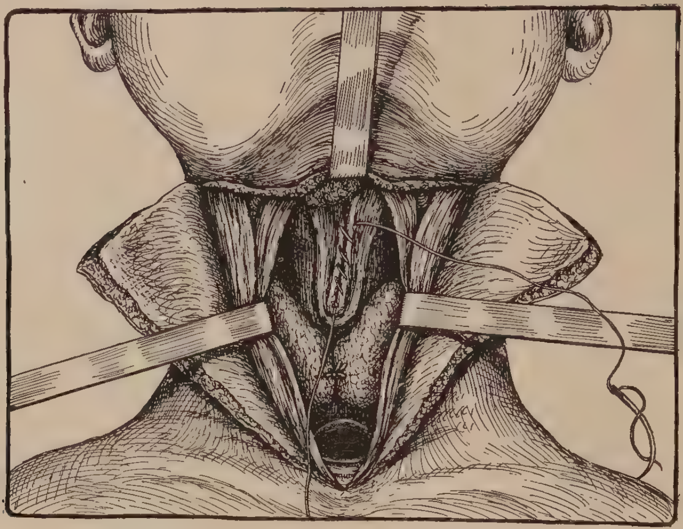

FIG. 5.—COMPLETE LARYNGECTOMY. CLOSURE OF PHARYNX.

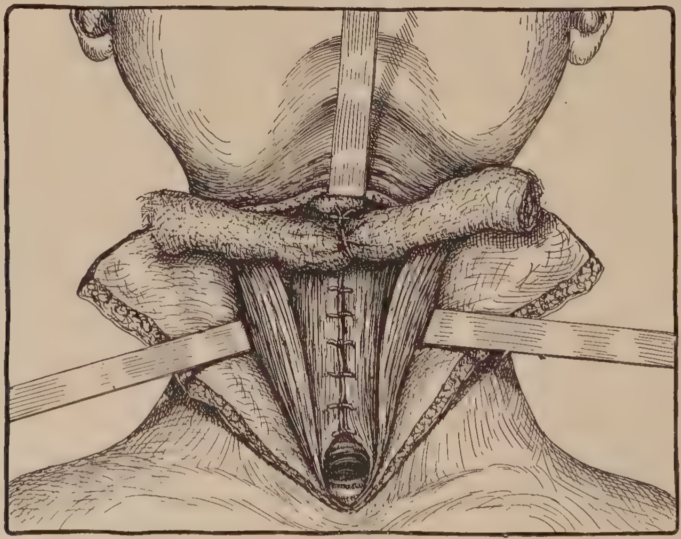

FIG. 6.—COMPLETE LARYNGECTOMY. CLOSURE OF STERNOTHYROID AND STERNOHYOID MUSCLES OVER PHARYNX AND UPPER PORTION OF ESOPHAGUS. This barrier of tissue is interposed between the drainage above and the trachea below. The posterior border of the trachea is now brought forward and sutured to the skin. The anterior border of the trachea at this point has been sutured to the skin ever since the preliminary tracheotomy.

> raised up and the attachment between the larynx and the esophagus is divided with knife or scissors. In a short, thick neck, the wings of the larynx which extend down laterally to protect each side of the esophagus, are divided with scissors. The dissection is then carried upward until the upper end of the larynx is reached, where its posterior wall becomes fused with the anterior wall of the pharynx. The upper end of the larynx is then cut free, the larger arteries being severed at the very last. Hemostasis must be most thoroughly observed throughout the entire operation. If the cancer is intrinsic, the lymphatic glands which drain the diseased zone should be carefully removed with the larynx itself."

After the operative procedure has gone so far as to remove the larynx, the question arises as to what is to be done with the very large wound which now remains. An effort should be made to close the pharyngeal wound completely, or, this being impossible, to close it around a rubber tube (Gluck's funneled feeding tube) which will carry the secretions into the esophagus. The upper end of the trachea should be brought forward and sutured to the flaps of the skin on either side, closing off with the soft tissue the upper part of the wound from the tracheal orifice, or, according to the method of Gluck, it should be placed in a separate buttonhole of skin and an effort made to close the wound off by stitching across, as a barrier, the sternohyoid and sternothyroid muscles. The rest of the wound should be packed with gauze and treated as an infected wound from the start.

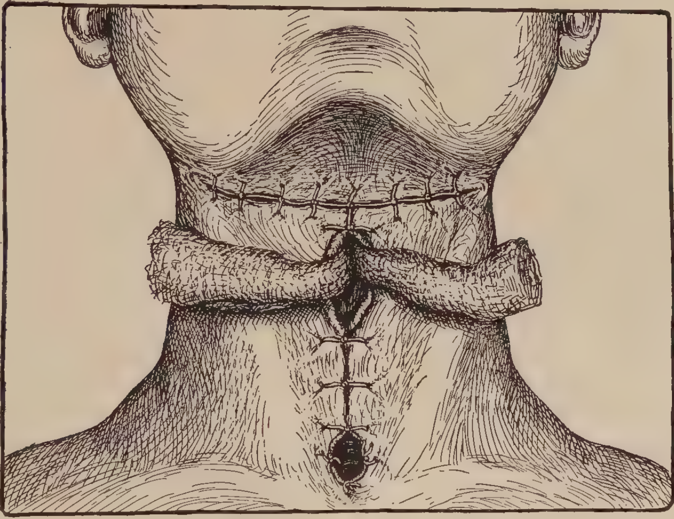

FIG. 7.—COMPLETE LARYNGECTOMY. CLOSURE OF WOUND WITH DRAINAGE ABOVE AND A BARRIER OF SKIN AND UNDERLYING TISSUE BETWEEN THE DRAINAGE OPENING AND THE TRACHEAL OPENING.

In regard to removal of the adjacent lymphatic nodes, Butlin in 1908 expressed the following opinion:

> "I think the glands ought to be removed in every case in which there is extensive carcinoma of the larynx, even if it be intrinsic, unless the disease is limited to the middle zone of the interior of the larynx. Even in these cases it would probably be a wise precaution to remove the glands. I have never removed the glands and the larynx at one sitting."

TRACHEOTOMY

A tracheotomy may be either high, low, or transverse. The high operation is above the isthmus of the thyroid; the low operation is below it; and the transverse one is over the cricoid cartilage (O. Frank).

Indications for High Tracheotomy.—High tracheotomy is done to relieve impending obstruction from any cause above the trachea. The dyspnea calling for it may be urgent or may be a progressive dyspnea due to some growth of long standing in the larynx. It is the situation of choice in children. Foulis of Glasgow has called attention to the fact that the isthmus of the thyroid is a negligible quantity in children and can be severed between two clamps. Its presence may be ignored and behind it lies the best place for entering the trachea.

Further indications for a tracheotomy in this situation are: to aid in the inspection of the trachea and to aid in the removal of foreign bodies from the trachea or bronchi. The inspection of the trachea and its bifurcation can easily be done by means of a urethral speculum and a head light. In some instances it may be possible to introduce forceps directly through this opening and remove a foreign body. A high tracheotomy may also be done for the removal of growths from the trachea, such as fibromata or fibrosarcomata, or in the other direction for growths of the larynx. Some authorities recommend that it be done as a preliminary procedure before partial or complete laryngectomy for cancer. It is also done as a therapeutic measure to place the vocal cords at rest when they are the seat of papillomata.

Indications for Low Tracheotomy.—Low tracheotomy, that is, below the isthmus of the thyroid gland, is indicated in obstructions of the glottis in adults and is placed low in order to avoid the thyroid isthmus, which in some cases is more prominent and liable to cause embarrassment from hemorrhage during the procedure. This also is done as an aid to the inspection of the interior of the air passages. Either a high or low tracheotomy may be done to aid in the expulsion of a foreign body by coughing. Low tracheotomy is the preferable procedure for tracheotomy which precedes total laryngectomy, as it allows of better separation from the laryngeal wound. There are, however, certain precautions to be taken in doing it. One must be careful not to wound vessels which may be aberrant or enlarged. The thyroidea ima may be in the way. The innominate artery may be encountered as high as the seventh ring. The inferior thyroid veins are larger and the trachea is more motile at this point. There is greater danger of infection of the mediastinum from the propinquity of the negative pressure in the chest cavity, and the thymus gland may be encountered in young subjects. (J. Wood, 39.)

Indications for Tracheotomy in Diphtheria.—At the present time the proportion of recoveries after tracheotomy in diphtheria is about 63 per cent. (4). In this disease dyspnea is the cardinal indication for the operation. Some authorities go to great lengths to describe the different forms of dyspnea, the presence or absence of particular types of which will affect the prognosis, should tracheotomy be done. The operator must be guided by his personal judgment and his appreciation of the physiology of the respiratory mechanism. Naturally, when the patient, be it a child, is suffering from an urgent dyspnea and the lungs appear clear and resonant, one immediately thinks of laryngeal obstruction and of a tracheotomy. If, on the other hand, the patient is pale or "livid" and on listening to the chest there are well-marked signs of pulmonary congestion, not to say edema, one must necessarily think of terminal exhaustion caused by too long delay in interference, and at this point tracheotomy will do very little, if any, good. It is, therefore, a better rule, if one is not prepared to do an intubation or is unfamiliar with that procedure, to do a tracheotomy early in the onset of the dyspnea rather than to delay until exhaustion has commenced because of waiting for a fine distinction to be observed between the forms of dyspnea.

General Considerations.—Before proceeding to the operation, a few words of caution are in order and a few general points may be laid down:

First, there should be an ample incision in the skin in order to avoid the subcutaneous emphysema which may otherwise occur, and to give better access to the immediate field of operation.

Second, the operator should keep accurately in the middle line, for going to one side or the other may result in failure to open the trachea properly and may greatly increase the hemorrhage.

Third, the trachea should be steadied by an assistant if present, and if not, by the left hand of the operator, when it is being cut down upon.

Fourth, hemorrhage should be avoided as much as possible and all active bleeding stopped before opening the trachea, as a small amount of blood coupled with the mucous secretion of the trachea may act as a movable diaphragm in the lumen of the windpipe, which prevents the interchange of tidal air and drowns the patient.

Fifth, one must be sure that the tracheal fascia is properly cut and that the cannula is inserted fairly and squarely.

Sixth, if the breathing be not improved at once upon opening the trachea, the trachea should be aspirated with a suction apparatus, or swabbed out with a feather, or both.

Technic.—The incision for tracheotomy extends from above the cricoid cartilage in the median line in a longitudinal direction for 1½ in., with its middle over the first tracheal ring. The sternohyoid and sternothyroid muscles are retracted from the median line, and the isthmus of the thyroid is pushed downward and all bleeding vessels are caught and ligated. The trachea is then opened either by cutting transversely across the front of the trachea between the first and second tracheal rings, or by cutting longitudinally through the first and second rings. A specially designed forceps has been made to slip in at this juncture and hold the tracheal edges from being pushed backward when the tube is inserted; an ordinary hemostat introduced and opened will serve the same purpose.

Care must be exercised in making the proper selection of the size of the tube. Foulis of Glasgow (16) had a set of 5 different sizes to fit any given case from birth onward, which he could select at a moment's notice. There is also a choice of material to be used. Some prefer a curved soft rubber tube which just fills the opening; others prefer a double silver tracheal tube which permits of the removal of the inner tube for cleansing; and others use a hard rubber tube. When the tube is well in place, it should be secured by a tape which goes around the neck to keep it from coming out. If a hard rubber tube is used, care must be taken to see that there is no danger of it falling into the trachea, that is, it should be obtained from a reliable firm with this danger in mind. This accident has been reported and is a very awkward complication of this operation. All tubes should be inspected and it should be made sure that they are well made before they are used.

When once the tube is in place, a gauze dressing is kept around it to prevent, as much as possible, infection from the outside. This should be changed at least twice a day. When the tube becomes filled with mucus, it must be cleaned by removing it and boiling for a few moments, if the material permits, and if there is much rattling and a tendency to cyanosis from obstruction to the trachea from secretions, the tube and trachea must be swabbed with a clean feather. This is as safe to use as anything, as there is little danger of particles becoming detached and causing irritation in the trachea. It is also well to have some form of mechanical suction present, which may be exerted by means of a small flexible catheter through the tracheal tube. This may be the means of preventing the patient from drowning in his own secretions (Chevalier Jackson, 27).

Complications.—Complications arising in the course of tracheotomy are: (a) Inhalation of blood and discharges from the wound, causing bronchopneumonia, tracheobronchitis, and ordinary tracheitis; (b) decubitus of the trachea from pressure of the end of the tube on the back of the tracheal wall; (c) detachment of the tube, which then falls into the trachea and becomes a foreign body and, as such, must be dealt with according to the treatment of foreign bodies. This last causes an alarming condition, often putting the patient to the verge of suffocation. Should it occur, the first expedient is to invert the patient, rapping him sharply on the back, retracting with a thread around the neck the edges of the tracheal wound, and losing no time in securing a pair of forceps with which to seek the foreign body at the earliest possible moment.

When a tracheotomy has been done for papilloma of the larynx, it is often the case that a mass of papillomatous tissue springs up about the tube. This should be cut down and burned with a caustic from time to time to prevent clogging of the opening of the tube.

After-treatment.—In the after-treatment of tracheotomy, as in all operations for opening the air passages, the attending physician must strive to avert the common complication of pneumonia. To avoid this, attention must be paid to the secretions from the wound, keeping the external wound clean and dressed twice a day, or oftener, with moist dressings: keeping the trachea free from the viscid secretions which tend to accumulate and which cause a rattling and coughing. When these secretions are present and cause embarrassment, the inner tube of the cannula, if it be made after this pattern, must be taken out and cleansed, and a feather swabbed down the trachea until the breathing is free and the patient is at ease again.

Aside from the special treatment of the wound, the general condition of the patient must be looked after. He must be kept comfortable and fairly warm by means of bed clothing, but the temperature of the room should not be above 70° F. If there is a tendency for the secretions to dry around the tube, the addition of some moisture to the inspired air will prevent this. Inhalations of steam from a pint of boiling water upon which has been poured a teaspoonful of compound tincture of benzoin may be utilized, but it seems better to keep the patient comfortable rather than to place him under a tent in which a steamy atmosphere is continually maintained, as is frequently recommended. The patient's nutrition must be kept up and one of the means indicated may be feeding with the catheter through the nose.

In acute cases after the fifth day, one must think of removing the tube. The time for this is governed by the amount of secretions present. If the tendency to excessive secretion has ceased, then the tube may be removed. This will be found generally to be from the fifth to the tenth day. Cases that have been a long time coming to tracheotomy will have to be dealt with more slowly, depending upon the progress of the condition for which the operation was performed.

ABLATION OF THE TRACHEA

Gluck (18) has practiced ablation of the trachea for primary carcinoma. Tumors of the trachea, both benign and malignant, are, however, extremely rare, according to von Bruns (6), the proportion being 1 tracheal tumor to 100 laryngeal tumors (Sauer, 35).

BRONCHOTOMY THROUGH THE POSTERIOR MEDIASTINUM

Indications.—This procedure should be attempted only after a foreign body has been located, either by the X-rays if it is opaque to them, or with a certain degree of accuracy by means of a tracheobronchoscopy. If the object is not seen by the bronchoscopy, at least it may be possible to detect pus coming from one or the other bronchus, indicating that it is near the site of the foreign body.

The indications for bronchotomy through the posterior mediastinum are foreign bodies impacted in the bronchus, or of long standing, which cannot be removed by means of an upper bronchoscopy or by a bronchoscopy through a low tracheotomy. (The suggestion has been made that this form of bronchotomy may be utilized to prolong life in cases of growths which slowly obliterate the trachea. The opening is made into the bronchus and a long jointed tube is passed in to establish an air passage. It would seem of doubtful utility.)

Bronchotomy through the posterior mediastinum may be performed for entering the right main bronchus or for the left one. The procedure differs slightly on the 2 sides.

The procedure here described follows the method of Anselm Schwartz, with some minor modifications.

Technic.—RIGHT POSTERIOR BRONCHOTOMY.—With the patient lying on the side on which the operation is to be done, and the corresponding arm hanging over the edge of the table to retract the scapula, a curved incision is made over the 3rd, 4th, 5th, and 6th ribs, making a flap with the base toward the axillary line. The convexity of the flap should pass slightly beyond the spinous processes of the vertebræ. The skin, fascia, and muscles are included in this flap right down to the transverse processes of the vertebræ and the ribs. The erector spinæ muscle is separated from the vertebræ and drawn outward. When the outer border of this muscle is reached, the ribs are denuded more easily. With rib-cutting shears, the 3rd, 4th, 5th, and 6th ribs are divided near their attachment to the vertebræ. The muscles and ribs are then sep-

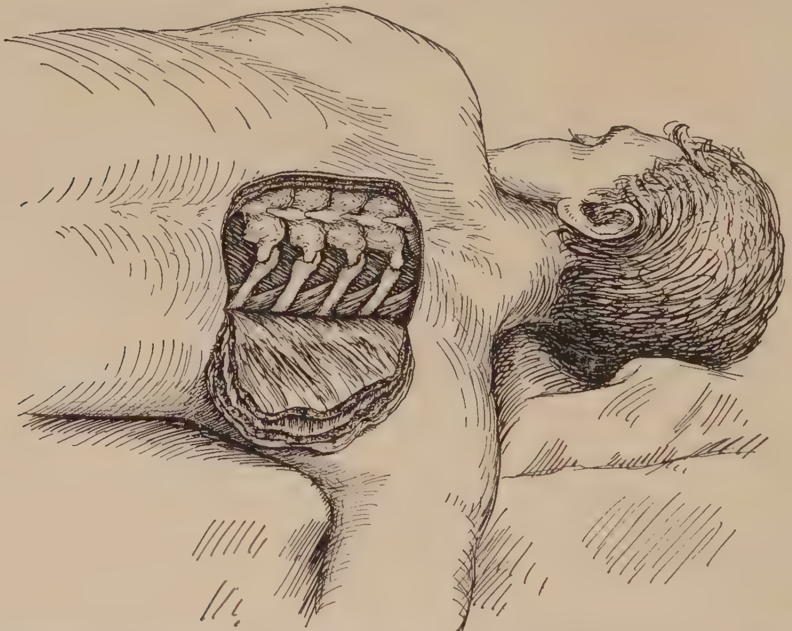

FIG. 8.—POSTERIOR BRONCHOTOMY. INCISION AND FLAP. The third, fourth, fifth and sixth ribs are exposed posteriorly. The edge of the flap goes well past the median line. (From original dissections.)

arated from the nerves and intercostal vessels, which lie at this juncture, about 1 cm. anteriorly. These can easily be saved, if one so desires, by stripping the ribs from them outward. A portion of the ribs and intervening intercostals are then removed for a space of about 5 to 7 cm. from above downward. They are not replaced. (This method gives a better field of operation in the depth of the chest.) With the fingers pressing toward the vertebral column, the parietal pleura is stripped from the vertebral column upward and downward and forward until the esophagus is in plain sight. In about the middle of the wound the azygos vein is seen crossing the esophagus. The lung and parietal pleura are now retracted outward so that the azygos vein is well exposed. The vagus nerve will be seen lying on the esophagus, running in the same direction as it. The small bronchial artery lies about 2 cm. below the azygos vein. With the index finger and at a depth of 7 cm. in an adult, will be felt the posterior extremities of the rings of the right bronchus, in the space bounded above by the azygos vein, below by the small bronchial artery, to the left by the esophagus and to the right by the lung. This may then be grasped by a tenaculum or volsellum forceps and opened with a sharp scissors in the direction of the axis of the bronchus. A search may then be made for the foreign body with forceps introduced into the bronchus. If a peribronchial abscess exists, drainage may be established by means of a very soft tube in this locality.

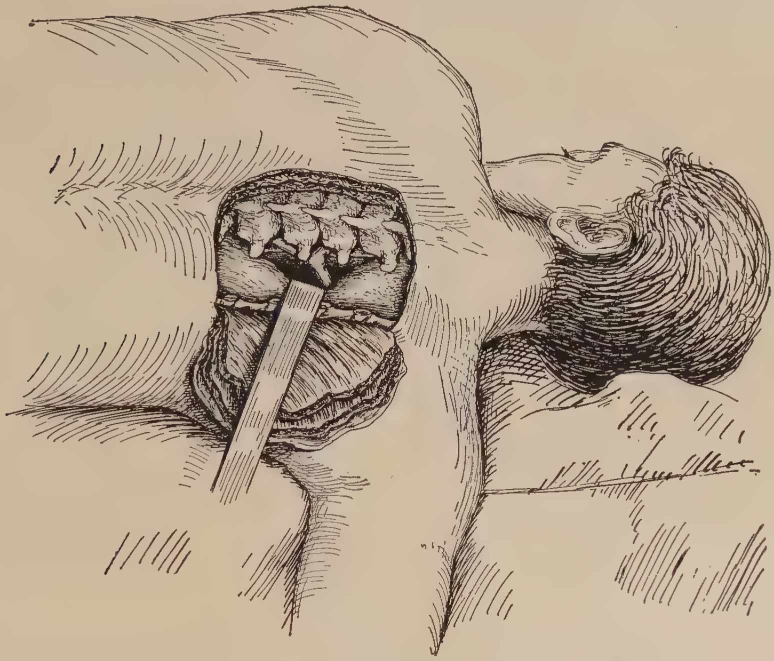

Fig. 9.—Posterior Bronchotomy. The Pleura is Here Shown Drawn Outward with a Retractor. The azygos vein is here seen crossing posteriorly to the esophagus. The vagus nerve lies on the esophagus. (From original dissections.)

LEFT POSTERIOR BRONCHOTOMY.—The same number of ribs is exposed by a similar flap, the parietal pleura is separated upward, downward, and forward to the vertebræ in the same manner as on the right side, but here the first large structure to be encountered is the aorta. Following this up, the arch will be found going forward to reach the anterior mediastinum. Under the arch will be felt the left bronchus at the same distance from the surface of the ribs and by the same means of touch. The method of opening is the same as on the opposite side. If the bronchus has been opened, it is better to close the wound with drainage on account of the probability of suppuration accompanying the presence of the foreign body for any length of time in the lung.

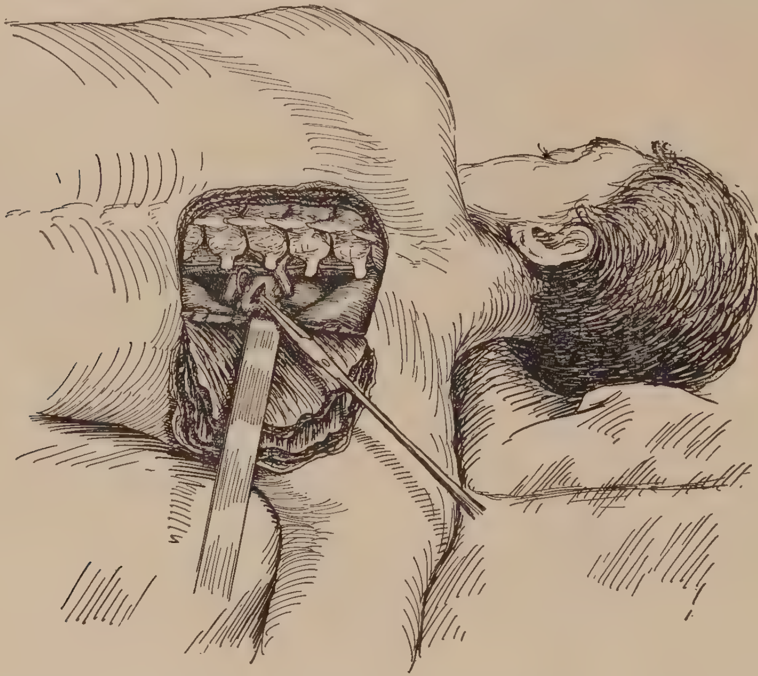

FIG. 10.—POSTERIOR BRONCHOTOMY. RIGHT MAIN BRONCHUS HERE LIES EXPOSED AND OPENED. Above it is the azygos vein; below it is the small bronchial artery. It lies at a depth of seven centimeters from the surface and is at first most readily recognized by touch. (From original dissections.)

Bronchotomy Through the Right or Left Chest Wall.—This is a very different procedure from a bronchotomy through the posterior mediastinum and involves entering or passing through the pleural space. The indications for bronchotomy through a thoracotomy wound are: a foreign body which cannot be reached in any other way, and the presence of a bronchiectasis. In either of these conditions one may encounter, on opening the thoracic cavity, adhesions between the lung and the pleura, or the field may only be partially guarded by adhesions. If the foreign body is of only recent lodgment, there will be no adhesions from it.

Differential pressure may or may not be employed, depending largely upon the age of the patient, upon the length of time the foreign body has been present, causing a local reaction or adhesions, and upon the familiarity of the surgeon with it. My own preference would be to use the intratracheal method of differential pressure, especially when children are being operated upon, as a child will bear the opening of one pleura with less freedom from respiratory embarrassment than will an adult, owing to the greater motility of the mediastinal structures. The intratracheal method of anesthesia largely puts at rest the movement of respiration and insures for the operator a more quiet field than would otherwise be encountered. The advice of some surgeons is to attack the larger bronchi directly if the foreign body is to be removed, using much the same method of procedure as in the removal of stone from the pelvis of the kidney through the wall of the pelvis of the kidney. My own preference, however, is to pass through the lung tissue to the bronchus, provided the body is as deep as the secondary bronchi, and extract it through the lung, in much the same way as a kidney stone is removed by splitting the kidney, a procedure advocated in the earlier days of kidney surgery. The hemorrhage which may result from this can be controlled by packing, or, if the operation proves to be free from visible pus, by a series of buried purse-string sutures of catgut, closing the visceral pleura with continuous stitching much as any wound is closed by a continuous stitch, which is also partly a retention stitch. Or the lung over the bronchus may be dealt with as suggested in my report of some laboratory experiments in 1906 (20). The chest should then

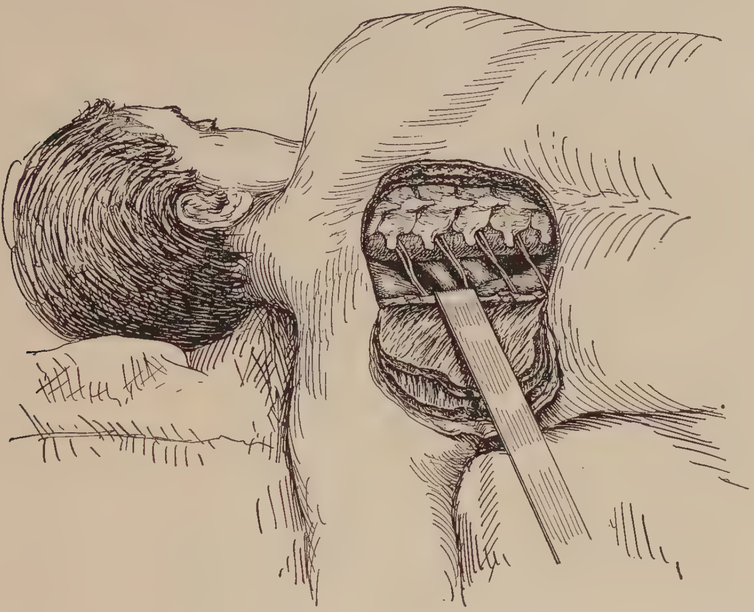

Fig. 11.—Left Posterior Bronchotomy. In this cut the intercostal nerves and vessels have been preserved. The left main bronchus is seen lying anteriorly to the aorta and below the pulmonary vessel. (From original dissections.)

be closed tightly and the patient watched carefully for development of any fluid in the chest, which, if not purulent, will be absorbed.

The site of the thoracic incision should be determined by the physical signs and by the position of the foreign body, if opaque, as shown by the X-rays. The incision taking out the sixth rib allows access to the lower part of the chest, and the one taking out the fourth rib will allow access to the bifurcation of the trachea and to the primary and secondary bronchi on the side in which the incision is made. If the operation is being done under differential pressure, the pressure can be momentarily discontinued while the lung on the side in question is allowed to collapse, and the palpation of the root of the lung is carefully done.

In bronchotomy for lung abscess or bronchiectasis, one is dealing with quite a different entity and the method of operative procedure must be modified to meet the conditions of suppuration which are present from the start. This holds true also if the abscess surrounds a foreign body. In these unclean conditions the favorable outcome of the operation is materially aided by the presence of adhesions. If on opening the chest wall, these are found to be present, one can proceed cautiously by a blunt dissection in the direction of the depth of the lung. If, however, these adhesions are not present, it is wiser to do a two-stage operation. At the first sitting explore the lung by palpation and afterward produce adhesions between the visceral and parietal pleura by the application of some irritant chemical, such as Lugol's solution (Sauerbruch), to the visceral pleura, and stitch the visceral to the parietal, allowing the wound to close for the time being. After 10 or 12 days, the lung may again be gone through by means of blunt dissection until the bronchiectasis is reached and can be drained. In this class of cases the rigidity of the chest wall should be overcome by removal of a number of ribs at this sitting or at a subsequent one to allow the lung and its contained cavity to collapse.

The after-treatment of this condition is to keep the tract open and allow the secretions to escape until the discharge becomes less profuse, and then to cautiously inject into this bronchial fistula a paste made of vaselin and iodoform, from 10 to 30 per cent., at intervals, depending upon the condition and progress of the patient.

The complications may be empyema and pneumonia, which must be met according to indications, as in uncomplicated cases.

INTUBATION

Indications.—The chief indication for intubation and the one which is foremost in the minds of the medical profession is obstruction to breathing caused by laryngeal diphtheria. When a diagnosis of diphtheria is established and the patient begins to show signs of increasing obstruction to the free ingress of air, as shown by increased stridor and an anxious expression, with an increasing cyanosis of the skin, the time has come for intubation. In croupous laryngitis without demonstration of the Klebs-Löffler bacillus, it may also be necessary, in order to avoid suffocation, to insert an intubation cannula. Secondary strictures of the larynx may necessitate one form or another of intubation, but these should be more satisfactorily dealt with under the complications of the diseases of which they are an accompaniment.

Technic.—As this is most frequently done in children, it should be described as being done upon a child. The instruments required are a set of O'Dwyer intubation cannulæ, with the introducer and remover. No anesthetic is used, as the patient is already suffering from extreme dyspnea. The services of a strong and intelligent nurse are indispensable, as success depends upon the proper holding of the child and the quickness with which the procedure can be performed. The position of the patient is as follows: The nurse holds the child's feet between her knees, keeping its body upright with one hand, holding the head against her left shoulder and the other hand holding the 2 hands of the patient. The body should be anatomically straight up and down. As the patient is thus held, the operator sits on a stool facing the child and with the instrument fitted with a properly selected cannula in his right hand, he passes his left forefinger, protected by a bandage to prevent its being bitten, down to the child's epiglottis, which he then hooks forward. The instrument is then passed along the side of the left forefinger until the cannula is felt to rest upon the top of the larynx. There is a moment's pause and at a sudden inspiratory effort on the part of the child, the cannula is slipped into the glottis and the carrier released and withdrawn. The string which has been previously placed in the cannula is not withdrawn. It causes but little annoyance and is the means of safeguarding against the loss of the tube and also acts as a great aid in withdrawing the tube when the time has come to remove it.

The question will immediately arise whether the tube is in the right place or not. A very frequent accident is to place it in the esophagus, where it will do no good, but where it will do little harm for the moment. By introducing the finger after the cannula has been slipped off the holder, one can feel the position of the upper end. If the posterior part of the larynx can be felt behind the tube, the tube is in place. If this cannot be felt, the tube should be withdrawn and an attempt made to introduce it again. Naturally, too long and continued effort should not be indulged in. If it is impossible to introduce the cannula within a reasonably short time, Goodall (19) recommends that after 3 attempts at intubation without success, all further attempts should be abandoned and a tracheotomy should be resorted to at once.

Removal of the Cannula.—The average intubation, according to Rosenthal (34) is 120 hours. Rosenthal states that the cause of prolonged intubation most frequently is paralysis of the vocal cords, not that intubation causes paralysis. In the discussion of the same article, Dr. B. R. Shirley, of Detroit, states that in 261 intubations performed in diphtheria in the 5 years prior to March, 1902, he had only 8 cases where the tube was retained longer than his customary 4 days—in other words, only 8 cases where it was necessary to intubate again after the tube had once been removed. (From this, it is also clear that the O'Dwyer cannula as used in diphtheria produces no paralysis, even after 4 days in the larynx—Green, 20.)

BRONCHOSCOPY

The use of the bronchoscope is but one division of endoscopic work that has been developed generally in the last few years. One who is familiar with the use of the esophagoscope will naturally be able to do a bronchoscopy with greater facility and one who is accustomed to urethroscopies and cystoscopies will naturally fall more easily into the way of doing a bronchoscopy than one who has never attempted anything of this nature. Bronchoscopy is harder to master than esophagoscopy and far harder than cystoscopy, on account of the difference of the image presented. The tax upon the patient is severe. Upon the examiner it is also great in the matter of patience and manual dexterity; and it calls for great resourcefulness. By virtue of the difficulties that must be overcome it will not become a procedure to be placed in the hands of every surgeon, but a general description of this special branch of work is not out of place in a book of this nature.

Instruments.—The bronchoscope should be strong, in order to stand lateral strain in displacing the trachea, and simple in construction. It must have an adequate lighting system and tubes of different caliber. (A tube of 7 mm. outside diameter is about as small as can be used with satisfaction.) Most instruments have extensible tubes, which may be made longer by pushing them into the trachea by means of a spring or other device. The question of lighting is exceedingly important. A light thrown from the outside, either directly or indirectly by means of prisms and a mirror, has met with the greatest favor.

One should familiarize himself with the necessary apparatus and instruments before undertaking to use them, as, unfortunately, the instruments are more complicated than those for the ordinary procedures in surgery, and failure may occur by the failure to properly control the electric current.

In the instrumentarium are also included forceps of various shapes for various purposes—hooks, applicators, long sponge holders, etc. For a list of instruments one should possess before undertaking bronchoscopy, I will mention the following:

A *bronchoscope,* with two sizes of tubes and preferably outside illumination and electric control for attachment to the street current or a small dry battery with a controller attached to it. The latter is preferable, as it will avoid any shock from grounding of the current. (Mikulicz had a tube blackened on the inside. The apparatus of Killian is generally considered the standard instrument. Brünings has devised a very excellent bronchoscope embodying some of the principles of the endoscope of Kasper. J. Guisez (21) has devised an excellent headlight for use with the bronchoscopic tube. Lewisohn has devised on a different principle a very ingenious instrument, and one has been brought out by me.)

A pair of *long forceps* especially designed to work through the bronchoscope tube.

A long *suction tube.*

A suitable *mask* on which to drop ether for the continued anesthetization of the patient when the bronchoscope tube is in place.

A *curved applicator* for the cocainization of the pharynx and larynx.

A long, *straight applicator* for cocainizing further down the trachea.

A direct vision *laryngoscope* with a slide in the side of it to enable its being removed from over the bronchoscope tube. (The bronchoscopic tube is introduced through it.)

Extra lights for illumination, as it is very important not to have to delay or to repeat the process.

A *strong wooden chair* with the legs sawn off, for the patient to sit in when a local anesthetic is used; and a *table* with a special head holder for general anesthesia.

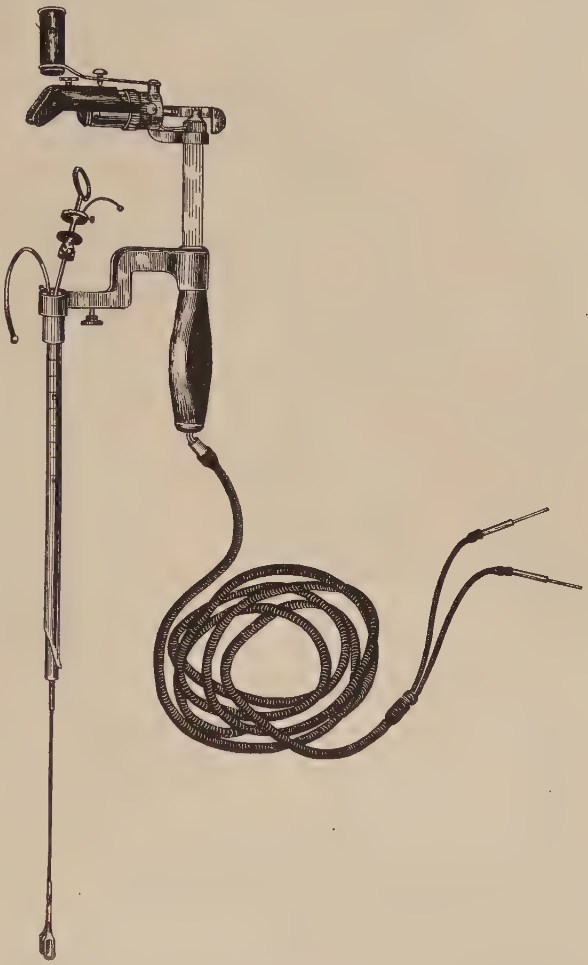

FIG. 12.—BRÜNINGS' BRONCHOSCOPE. Special forceps passed through the tube.

A small *electromagnet* for introduction into the trachea in case the foreign body may be of iron or steel.

Other instruments may be accumulated or made as occasion demands.

Before performing either an upper or a lower bronchoscopy upon a living patient it is well to do some preliminary work on a cadaver or on dogs, or on a phantom tracheal and bronchial tree.

Technic.—LOWER BRONCHOSCOPY.—The procedure is best attempted after preliminary practice upon a patient who has had a tracheotomy performed (Brünings and Howarth, 5). Examination through this opening will constitute what is known as a lower bronchoscopy. If this tracheotomy wound is recent, it is well to have the patient lying down. If it is an old wound, the patient may very well sit up and the bronchoscopy will be much facilitated by this posture. The examiner should familiarize himself by this means with the lower part of the trachea, and with the bifurcation and the right and left bronchus. By suitably displacing the trachea the tube can be entered into one or the other bronchus and the branching of the bronchi may be seen. (Before doing this examination, it is well to study the scheme of the bronchi going to the different lobes, in order that one may have a systematic idea of the steps to be taken in searching the bronchi from above downward on each side.) The right bronchus is the one to be first inspected, as into it fall most of the foreign bodies. The opening of the right upper lobe bronchus may be seen in passing the tube down the right bronchial opening, but it is almost impossible to inspect the upper lobe bronchus with any satisfaction. The right middle lobe bronchus and the right lower lobe bronchus can be brought more easily into view and inspected. They can be seen to their bifurcations. The left bronchus is inspected by withdrawing the tube and passing it down the left bronchus by displacing the bifurcation of the trachea somewhat to the left side. In this case there are the lower lobe bronchus and the upper lobe bronchus to be inspected.

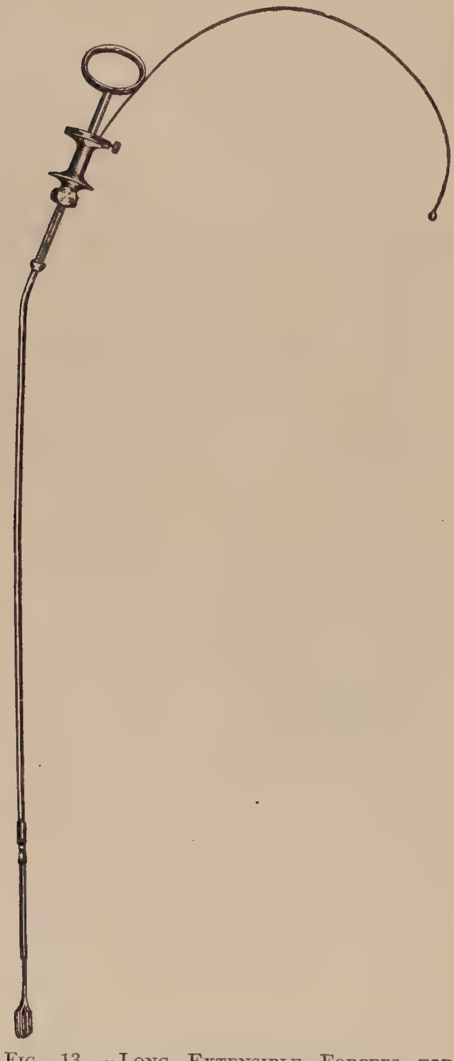
Fig. 13.—Long Extensible Forceps for Working through Bronchoscope. (Brünings.)

Besides utilizing a tracheotomized patient to start on, it is well to bear in mind that in any case we may be obliged to resort to a lower tracheobronchoscopy, when it is too difficult to do an upper tracheobronchoscopy, or if one does not feel satisfied with the findings through the upper route. It is by far the easier procedure, but of course entails the necessity of a tracheotomy wound.

UPPER TRACHEOBRONCHOSCOPY.—We now come to upper tracheobronchoscopy, which is a more difficult procedure. In this case the patient, if a child, is anesthetized at the time and in the same room where the attempt at bronchoscopy is to be made. The examiner should be in the room ready to pass his instruments at once should there be any dyspnea caused by the superimposition of the anesthesia. If an adult is to be examined, it is well to attempt at first to anesthetize the pharynx and larynx with a 10 per cent. cocain solution, or novocain 4 per cent. with adrenalin. (The latter takes about 30 minutes to produce working anesthesia. I have had good success in the mucous membranes by this method, notwithstanding the unfavorable criticism of it as an anesthetic in this locality.) Twenty minutes should be allowed before an attempt is made to pass the instrument. If the local anesthesia is sufficient and the patient conscious, the position for the examination may be semi-upright with the body inclined forward and the head extended, but not to such a degree as to curve the cervical spine. Or the patient may lie on his left side with the knees drawn up and the head extended and held by the assistant or by a special head-holder. If a child and unconscious, the patient should be on his back with the shoulders at the end of the table, so that the head may be well thrown back and the neck lifted forward (Boyce's position, 26).

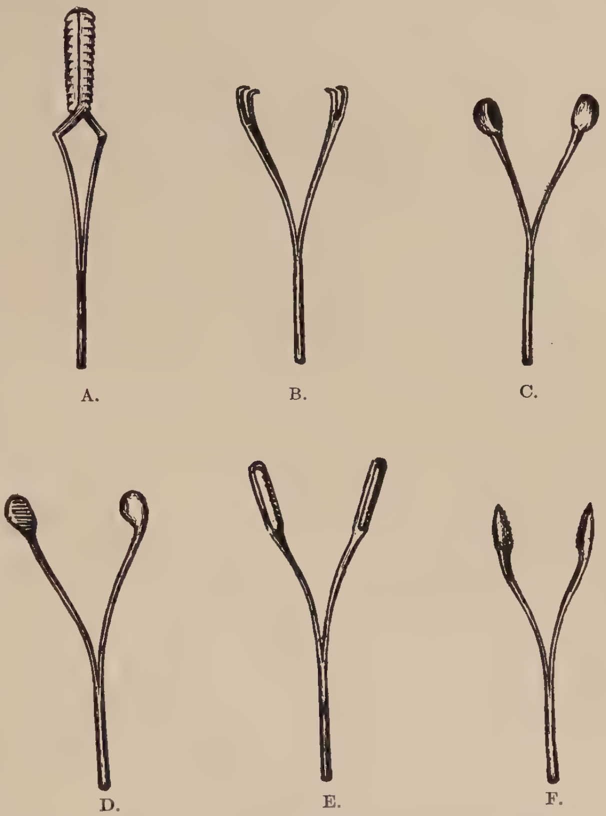

Fig. 14.—Various Tips or End-pieces for Attachment to Forceps. A, Brünings' hollow body forceps; B, claw forceps; C, modified Guisez forceps; D, von Eicken's needle forceps; E, Killian's bean forceps; F, flat body forceps.

Passing of the Instrument.—All instruments should be sterilized before commencing. The bronchoscope should be lubricated with a suitable lubricant and passed by direct vision into the pharynx, at first nearly at right angles to the axis of the trachea, encountering first the anterior wall of the epiglottis; then slipping over this into the upper part of the pharynx, the distal end is directed forward, i. e., the handle of the instrument is raised toward the head and the tube assumes more nearly the direction of the axis of the trachea. As the arytenoids are approached, one will see them move and perceive the rush of air with its characteristic whistling sound against the end of the tube. By paying attention to this sound, one can approach with ease the rima glottidis and pass the instrument between the vocal cords. To do this, when the arytenoids are encountered, the instrument should be withdrawn until the glottis is seen, and, watching for a favorable moment, it should be slipped through the glottis as it is opened with an inspiration. The wedge-shaped tip of the tube facilitates its passage between the cords. If it is impossible to introduce it as described, a direct vision laryngoscope should be used. The bronchoscope can be slipped in through this instrument and the laryngoscope withdrawn by means of the slot cut in the side. (As the end of the tube comes more nearly over the chink of the glottis, more air is encountered rushing through the tube. If the operator is wearing spectacles, the eye will be clouded by steam from the breath. This can be prevented by dipping the glass of the eye used in a weak solution of liq. cresol comp. U. S. P.—10 gtt. to the ounce.)

After passing the glottis, it is a simple procedure to go down to the bifurcation of the trachea and there inspect the left and then the right primary bronchus.

On entering the trachea, one sees the rings appear. If the tube be aimed too far ventrally, the anterior wall of the trachea is encountered and the rings appear to run straight across the end of the tube. If aimed too far dorsally, the posterior smooth wall appears to bulge into the field of vision. When it is advanced properly, the rings of the trachea should appear to go circularly around the field of vision. By turning the head to the right side and carefully advancing the tube, one can go down the left bronchus to its bifurcation into the secondary bronchi. Then the tube is withdrawn and, entered on the other side, it is passed through the right bronchus and to the secondary bronchi. It is possible now to explore the secondary bronchi to their bifurcations. Chevalier Jackson has a diagram for mapping out the bronchi on either side so that by keeping track of the branchings of the bronchi, a faithful examination of the secondary bronchi may be made.

Removal of Foreign Bodies.—If a foreign body exists in the trachea or bronchus, the next procedure is to extract it with the aid of the bronchoscope. This procedure is much more difficult than merely direct inspection of the tract, and requires forceps of various shapes, as before mentioned, in order that, if one fails, another may be tried. As a rule, forceps whose jaws close and open more nearly parallel are the ones to be used, as those having short jaws and closing and opening at a wide angle tend to push the object away without grasping it.

General Rules.—It is hardly in the province of a chapter of this kind to go into detail on this subject, as proficiency is acquired in this, as in other branches, only by means of practice. Very many special instruments are required. The operator is continually adding new ones to his case of instruments. There is also no hard and fast mode of procedure, as the operators in this line are comparatively few, and each one depends largely upon his own special skill and judgment for developing his own technic. There are, however, a few general rules that may be laid down:

First, this procedure is better done in a hospital than in an out-patient department or in one's own office. Preparation for a tracheotomy should be made in case of necessity.

Second, one should have at least two competent assistants present.

Third, the position of the patient is very important and must be maintained rigidly while the examination is being done, as any slight turn of the head by the patient may cause him injury.

Fourth, the apparatus and instruments should be carefully gone over immediately before attempting to pass the bronchoscope. This includes the pump, rheostat, electric lamps, forceps, and, in short, every instrument that is to be used.

Fifth, the procedure is best done in a darkened room.

REMOVAL OF FOREIGN BODIES IN THE TRACHEA AND BRONCHI

The presence of a foreign body in any of the upper air passages is an alarming condition and requires immediate intervention. The point of lodgment of the body is generally in the ventricle of the larynx, or, if it passes the larynx, then at the bifurcation of the trachea or within the lumen of the right bronchus next the division of the secondary bronchi. Cases are on record where a metallic object has remained in the bronchus for a number of months or even years with very few symptoms, but which has in time caused symptoms pointing to a bronchiectasis with a more or less localized pneumonia. It is, however, the exception for a foreign body to remain in one of the air passages for any length of time without causing very grave symptoms—even a pneumonia. H. J. Davis (12) advocates a more general use of the bronchoscope in general diseases and says unilateral bronchitis is often due to an unsuspected foreign body in the bronchus. Therefore, if a patient gives a history of having inhaled a foreign object—"swallowed it," as patients sometimes say—and not having coughed it up again, all means should be taken to locate the object and, when located, to extract it.

Chevalier Jackson (28) says: "In bronchial cases the chance of removal, if seen at once, is good. After twelve hours, when the body becomes buried in the swollen mucosa, the chances are less. . . . If not removed, the patient has only a fair chance of escaping fatal abscess, bronchitis, bronchopneumonia, and traumatic infective pneumonitis."

Foreign bodies divide themselves into two classes, with variations between these two classes: (a) those opaque to the X-rays; (b) those which transmit the

X-rays, in other words, those which are not found when radiographing the patient.

If the object inhaled is known to be of a mineral or metallic nature, it is advisable at once to have the patient X-rayed and the X-ray developed immediately. This gives a chance for early search for the foreign body. Metal objects will cast a clear shadow; glass of a certain percentage of lead may also be detected. If the object is shown by the X-rays, a few measurements are taken of the distance in the X-ray plate from the teeth or upper alveolar border to the point in the plate where the object appears. Then a point on the outside of the chest, corresponding to this distance, is marked with a black pencil. (In a child 8 years of age, 118 cm. tall, the distance from the upper incisor border to the bifurcation of the trachea was 16 cm.—head extended—at autopsy.) The patient should then be hastened to the operating-room and, if a child, placed under the influence of a general anesthetic. By the aid of the bronchoscope a search should first be made in the air passages for the object. Having found it, an attempt should be made to extract it with specially devised forceps through an upper bronchoscopy. If this fails, it is best not to prolong this procedure too far, but to do a low tracheotomy, enter the tube again through this opening and make another attempt to remove it with forceps. Should this fail, the tracheal opening should be held widely apart by means of silk sutures passing around the neck, in order that, if the object be loosened, it may be coughed out through the tracheal opening. If there is no opening, the object may be coughed up against the lower aspect of the vocal cords and again cause choking and spasm of the glottis, which prevents it from being expelled. The tracheal opening, therefore, aids materially in the expulsion of the offending object. If the foreign body is of a type that is not opaque to the X-rays and consequently does not show in the X-ray picture, such as a piece of nut meat, a bean, pea, or nut shell, or even a small button of one kind or another, no delay should be caused by waiting for the X-ray picture, but the surgeon should proceed at once to a direct inspection of the larynx, trachea, and the bronchi with the endoscope. (In one of my cases an Italian child had "swallowed" a button. By the X-ray nothing could be seen of it, but a constant sibilant breathing suggested some obstruction to the interchange of air. The button was found lodged in the entrance to the esophagus just behind the larynx. It was a coat button of bone 1.5 cm. in diameter, but had cast no shadow by the X-ray.) If the object is of iron or steel, it may be possible to pass a specially devised electromagnet into the trachea and draw it out by this means. Chevalier Jackson has suggested placing the patient, inverted, in the magnetic field of a powerful solenoid. Much depends upon the ingenuity and special training of the operator in these cases.

The complications of foreign bodies in the trachea and bronchi are pneumonia—rapid and fatal; abscess of the lung; bronchiectasis; perforation of the bronchus or trachea, with mediastinal abscess. In some of these complications, where the body has remained long in situ, it may be necessary to perform a thoracotomy and a bronchotomy or a pneumonotomy through this route.

F. S. Mathews (32) reports a case in which the foreign body, a staple, or two-pointed tack, was located by means of the X-rays, and an attempt made to extract it after it had lain unsuspected in the lung for months. In this attempt the object was recognized for a moment by the finger, but it could not be recovered through the chest wound. It was immediately coughed up by the patient, evidently having been dislodged by the examining finger at the time it was felt.

In the hands of the surgeon untrained in tracheobronchoscopy, it doubtless would be better to do a tracheotomy at once in cases of foreign bodies in the trachea or bronchi and to make an inspection of the respiratory passages by means of a short bronchoscope, or, lacking that, a tube, similar to a urethral speculum, and a head light. After all these means have failed, it may be that the body can be felt and extracted by means of long forceps.

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SURGERY OF THE NECK

CHAPTER IX

SURGERY OF THE NECK

Frank S. Mathews

GENERAL ANATOMICAL AND SURGICAL CONSIDERATIONS

Anatomical Considerations.—The neck consists of a central bony core which protects the spinal cord, around which are distributed a goodly number of important structures. There are the vessels supplying blood to the brain; cranial nerves which are necessary to the continuance of life; thyroid and parathyroid glands, which are to be reckoned as vital organs; and the two mucus mucosa-lined tubes, trachea and esophagus. With the bony support in the center and all these important structures covered only by soft parts, one's first thought would be that they were especially liable to trauma, but such is not the case. The bony framework of head and thorax protrudes in all directions in such wise as to be a protection. One by a scarcely voluntary effort flexes the head and elevates the shoulder to protect the neck at their expense. The skin covering is lax and elastic to permit the extensive movements of rotation, flexion, extension, and lateral motion, as well as movements of the mandible.

The neck has a larger supply of lymph-nodes than any other equal portion of the body. The head is practically without them, and those of the neck collect lymph for the head as well as neck. It must not be forgotten that the lymphatic drainage ends at the root of the neck on both sides in the jugular veins, and that there is no continuous lymphatic drainage through the superior aperture of the thorax into the mediastinum. Lymphatic infections end abruptly at the root of the neck. Clinical evidence shows their freest anastomosis to be across the shoulder into lymph-nodes of the axilla. This is also shown by the reverse course when cancer of the axilla extends to the supraclavicular glands.

The structures of the neck, while escaping trauma, are especially ill favored as regards infection. Infections of all anatomical varieties and of diverse bacteriology are found here. The infections enter much more often by the mucous membrane than by the skin, the adenoids and tonsils of children and the teeth and gums of adults being the less resistant points. The skin readily admits of inflammatory swellings beneath it but more deeply seated infections are controlled in their spread by the fasciæ that divide the neck into various compartments. The vessels and nerves of the neck show rare facility in escaping injury but the trachea is often subjected to pressure, and edema glottidis is one of the sudden and serious accidents which must be kept in mind when dealing with deep suppuration.

Anesthesia.—Operations on the neck present some special difficulties; perhaps the chief of these is the administration of the anesthetic. A position that gives a good surgical exposure may embarrass breathing. In drawing the jaw forward, the anesthetist's hands are in danger of invading the sterile field. To keep the anesthetist from the operative field one of the best means is to fasten the edge of a sterile towel with clamps or safety-pins to the skin along the lower border of the jaw; this towel then separates the anesthetist's and the operator's field.

Special anesthetic methods may also be employed, such as nasal, intratracheal and rectal—in all of which the anesthetist can be kept more out of the surgeon's way. Some surgeons have the anesthetist put on sterile gloves and use a sterile mask for the anesthetic but neither the hands nor the neck can be kept sterile long when brought in contact with the patient's face and mouth secretions.

Instruments.—The instruments used in neck operations are chiefly those used in any operation demanding careful, accurate anatomical dissection, such as scalpels; scissors of various sizes, curved as well as flat; artery clamps; blunt and sharp retractors; curved and straight needles and needle holders. The scissors devised by Charles Mayo have attained considerable popularity. Their blades are short and are ground down toward the end, so that when closed they are quite pointed. The closed scissors are thrust into a connective tissue plane and then opened in the tissue and in this way dissection is done following a natural cleavage plane. By this method even thin-walled veins usually escape damage by being peeled off the surface of a gland or tumor. The sharp retractors should be used only to retract skin, as they tear the deeper structures, such as muscle, and may puncture veins. For general use we may have a number of flexible spatular retractors which can be bent according to the needs of a case. Crile's small retractors (Fig. 1) have been found very suitable in gland dissections. Crile's clamps, too (Fig. 2), for temporary compression of the common or external carotid artery, are useful instruments, as with them we can produce just the desired amount of pressure on the vessel.

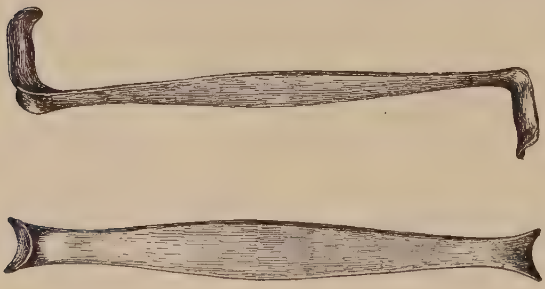


FIG. 1.—CRILE'S RETRACTORS.

Methods of Surgical Dissection.—It seems appropriate here to allude to the two methods of surgical dissection, *that with knife* and *that with scissors.* The users of the knife alone, as it were, magnify the training of the dissecting room, where with time, care and the knife alone the most perfect dissections are produced. They think that the beginner in surgery should be required to do his work with a knife in order that his dissections may be clear and anatomical. The scissors dissectors have in mind the end rather than the means; their dissections may not look as neat when completed, but as a rule much quicker work can be done with the scissors; there will be less bleeding, and when normal anatomy is obscured by a pathological process, the blunt dissection by means of opening scissors which have been inserted closed into the tissues may be the means of sparing an important nerve. Even a piece of gauze or the gloved finger may be used advantageously to make a quick division of tissues along a plane of tissue cleavage. We can work at times with comparative safety under a tumor by stripping with scissors where it would be necessary to see in order to use a knife. Practically, knife dissection requires a larger incision and better exposure of parts. The surgeon who wishes to be governed only by the practical will not fail to school himself in both methods, nor will he even eschew the blunt dissection with his gloved finger as being "unsurgical" if in a particular case it does the same work a little more quickly and equally as well as knife or scissors.

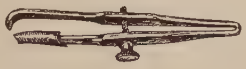


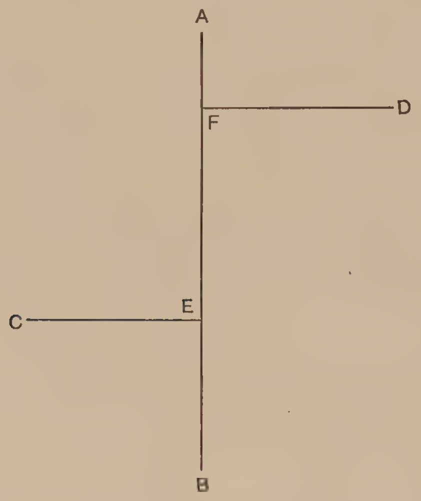
FIG. 2.—CRILE'S VESSEL CLAMP.

BURNS AND SCARS

Prevention of Scars Following Burns.—The scars resulting from burns are most unsightly and nowhere more so than in the neck, for there they cause various degrees of torticollis, drawing the chin downward, distorting the mouth, and interfering with the lips in speech. We should, therefore, make every effort to limit suppuration and hence the scar tissue formation in this region. No treatment seems so effectual in this regard as the treatment without dressing. To use this successfully, if the burn is extensive, a tent must be constructed over the patient and an electric lamp placed under it to keep the space warm. Moreover, this method cannot be employed unless insects can be kept from the burned area. Larval flies in a sloughing burn would make a very disagreeable complication. If the surface becomes too dry and crusts too firm, sterile vaselin or albolin may be applied.

As soon as possible grafts should be applied by the Thiersch method. They are especially prone to slip in this region because of the movements of the neck, hence the open method of treatment cannot easily be followed. The best substitute is to cover the grafts, after the method of Vosburgh (34), with narrow strips of sterilized adhesive plaster, placed practically in contact but with allowance made for wound discharge between them. The strips are long enough to get their hold on normal skin and hold the graft firmly in place. The same method applies well to the grafting of ulcer following carbuncle on the back of the neck.

Treatment of Scars.—When scars have formed, drawing the chin downward, we operate to release the jaw, but are likely to add to rather than diminish the area of scarred surface. Each case must be decided on its merits and the plastic operation required may be very extensive. Flaps with a pedicle made from the skin of breast or thorax may be used. When there is an elevated ridge of skin and scar tissue running from chin to neck, a useful method is to split the skin into 2 leaves by an incision running along the length of the scar, then dividing the two leaves by 2 incisions at right angles to the first incision but at different levels—one being divided close to the chin and the other some distance below, as illustrated in the accompanying diagram:



The line A B is the raised band of scar and skin. Along it from A to B incision is made. C and D represent 2 lateral incisions. Then by traction A and B are made to separate and E is drawn into the angle at D, while F is drawn to C. This elongates the neck scar but draws the tissues together laterally.

BOILS

Boils are more frequent on the back of the neck near the hair line than elsewhere on the body; they are due to one of the varieties of staphylococci and tend by their auto-inoculation to come in crops. When the boil is just making its appearance the practice of dermatologists is to seek out the hair through whose root the infection has entered, extract it, and apply pure phenol, dipping a match which has been whittled to a point into the phenol and then thrusting it into the hair follicle. They allege of this treatment that it aborts some boils and in other cases that the discharge through the opening thus made is facilitated.

The only other treatment for a boil that deserves trial is incision. Early incision relieves pain and tension, but the boil still has to run its definite course, ending with the separation of a slough and suppuration and taking about the same time for the process as it otherwise would, but the amount of destruction of tissue is much less than if it had followed nature's course. The pain of incision, however, is such that patients often refuse this treatment. In the first days the incision does not evacuate pus, but should be long and deep enough to relieve tension and permit a serous discharge. When the patient consents, the incision may be made by using a very sharp knife and making it as nearly instantaneous as possible. Ethyl chlorid to freeze the surface materially diminishes the pain of incision. Cocain cannot be used satisfactorily as the pain attending its injection is severe. A few breaths of laughing gas make the operation entirely painless. It is worse than useless to try to pack the incision. Bier dry cups have been recommended to be used immediately after making a small incision, but I have had no success with their use.

One treatment is mentioned because it is the one most in use by physicians and patients; that is, the flaxseed poultice. It is never to be recommended either before or after opening the boil, for it favors auto-inoculation.

A more important question than the treatment of the individual boil is the prevention of recurrence. Sunburn, scratching, and the rubbing of a dressing or collar aid in starting and disseminating boils. A wet antiseptic dressing—a surgeon's substitute for the flaxseed poultice—can also be depended upon to act as a skin irritant. If the reader has any doubt on the subject, let him try a weak carbolic or bichlorid dressing on the back of his hand. The hair follicles soon become red and pimples will form which subside on removal of the dressing.

When the boil threatens, the first thing to do is to cleanse the whole area with green soap and water used in abundance well up into the hair, or, better, with a complete shampoo. This is followed by bathing the skin with alcohol (50 per cent.). In neither case is the skin to be rubbed briskly. Before opening the boil, all the hair near by should be clipped short but not shaved. If the skin is clean, we may protect it by covering it with boric acid ointment in a ring about the boil so that pus from the opened boil is kept out of the follicles. Frequent dressings and cleansing, but without squeezing of the boil, are to be recommended.

If in spite of careful local treatment the boils recur, the use of a vaccine, preferably autogenous, is to be recommended. General poor health may be related to boils either as cause or effect, and in any case we are to attempt to improve it. It is in the persons whose health is otherwise good and in whom boils recur that the vaccines are to be recommended. Opinions seem to vary greatly as to their usefulness. The old remedy, "brewers' yeast." may be tried.

CARBUNCLES

Carbuncles demand prompt treatment before the patient gets into a desperate condition, where anesthesia is out of the question. Because of their serious possibilities, they should be viewed as serious from the beginning. Time is wasted by poulticing and injections of carbolic acid. If we get the better of the suppurative process early, we lessen the skin destruction and hasten healing, in some cases relieving the patient of the need of a subsequent skin-graft.

As a rule, gas or chloroform is to be used and the operation and anesthesia made as short as possible. Soap and alcohol are to be preferred to iodin for skin preparation. Radial incisions are made in the carbuncle and extended far enough to relieve tension. Then each of these tongue-like pieces of skin may be freed from the underlying necrosis by incisions parallel to the skin surface. The incisions are carried far enough to excite free bleeding, hence the wound should be tightly packed with gauze. At the first dressing this will be more easily removed if it is saturated with peroxid of hydrogen. After this there is no occasion to pack the depths of the wound with gauze. Should the process be extending in any direction, an additional incision or extension of incision should be made at once.

If diabetes is the predisposing cause, treatment that improves that condition will greatly favor the healing of a carbuncle. However, the sudden taking of a patient from ordinary diet and enforcing a strict diabetic one may bring about an acidosis soon to be followed by coma and death. On theoretical grounds, alkalies should do good, and clinical evidence favors their use. Bicarbonate of soda may be given by mouth or rectum or by intravenous infusion, but not by hypodermoclysis. Alkaline solutions given by hypodermoclysis in these patients are likely to cause pain and sloughing. See also Diabetes.

CELLULITIS AND LYMPHADENITIS

Infections in the upper neck are exceedingly common; the glands at the angle of the jaw are more or less continuously palpable in most school children. With colds and infectious fevers they enlarge, but usually demand no treatment but that of the exciting cause. In others there is a periadenitis, the glands fuse, and may or may not go on to the abscess stage. We must watch these cases with care to determine whether pus has formed or not. Before the matter is decided we may apply cold to the swollen area. Counterirritants, such as iodin, have their field in subacute or chronic processes, *not* in the acute, hence are not to be used. If used, the skin is made sore and the patient's discomfort increased.

Mild Cases.—In the milder grades of such inflammations where pus has formed deep in the neck it may be evacuated through a quite small incision. Make the incision transversely over the supposed location of the pus, and carry the incision to the deep fascia. At this stage we lay aside the knife and follow what is called "Hilton's method." A closed instrument, such as an artery forceps, is thrust into the tissue in the direction of the abscess, and when the point is felt to enter a cavity the forceps is opened and withdrawn, widening the passage. A drain, such as a cigarette drain or rubber band, is inserted, but a gauze one should not be used, as it plugs the opening and does not promote drainage.

When the pus has approached the skin, even if the abscess is large, it may be safely evacuated through a small incision (just a stab through the skin) in the cases where the process is not virulent, as shown by slight temperature, tenderness, or edema of adjacent soft parts.

Grave Cases of Cellulitis.—There are cases of cellulitis of the neck, however, that are exceedingly serious. They occur chiefly in adults and usually begin with trouble about the jaws—a Rigg's disease, an abscess at a tooth root, or extensive osteitis may be the starting point. Then succeed a periostitis and a brawny swelling affecting all the tissues from the jaw to the clavicle. It is difficult to open the jaws to any great extent, and the giving of an anesthetic is difficult and dangerous. Early incision along the anterior border of the sternomastoid or under the jaw is necessary. Incisions must be deep enough to relieve tension and so minimize the danger of an edema of the glottis. We must not wait until the pus is diagnosed; often it is present in very small amounts and the process remains throughout a rather long course as a ligneous edema only.

Ludwig's angina has been much discussed and differences of opinion prevail as to whether it is a disease of a special anatomical form only or due to a special bacterium. Its most emphasized character is that it involves the floor of the mouth, appearing to extend to it behind the mylohyoid muscle. It is very fatal, the result usually, but not always, being due to edema of the glottis. Extensive incisions both beneath the jaw and in the mouth are needed.

The instruments for a tracheotomy should be kept on hand and oxygen should be available for prompt use when needed. (In many of these cases I have been obliged to do a tracheotomy on the table or after a few hours.—EDITOR.)

HODGKIN'S DISEASE: PSEUDOLEUKEMIA

It is only in recent years that this disease has been clearly defined from other enlargements of lymph-nodes. The confusion has been largely one of names, of which this condition has had a great number, a name referring to the disease used by one writer often meaning quite a different thing when used by another. The confusion has been added to by the basing of a diagnosis on a microscopic section of a small piece of tissue removed for the purpose, since the appearances vary somewhat in different parts of the nodes. When a case is clearly Hodgkin's, a portion of a single node may yet show no lesions but those of hyperplasia.

It is sometimes difficult, both clinically and microscopically, to differentiate Hodgkin's disease from tuberculosis. The two conditions are at times associated in the same nodes and the occurrence has been so frequent as to suggest to some an etiological relationship. I have had considerable experience with Hodgkin's disease in children and have found that it does not respond to the von Pirquet test. It is best to think of the disease as a clinical and pathological entity, presumably an infectious granuloma, fortunately not very common and unfortunately always fatal. The fatal termination may be delayed from 1 to several years, and the disease from the standpoint of treatment may be divided into 2 stages. In the first there are no signs except the mass of nodes, in most cases located in some part of the neck. General health may be surprisingly good. In the second stage groups of nodes are involved anywhere or everywhere in the body and an anemia appears which becomes steadily progressive.

Both medical and surgical treatment have failed in permanently warding off the fatal termination. Arsenic seems the sheet anchor of the internist, but it would be hard to say why. Most of the cases which begin in the neck are subjected to X-ray or surgical treatment. The X-ray often causes a shrinkage of a group of nodes. On the other hand, they may remain stationary at least and probably recede at times under no treatment.

In the early days of the disease when there may be doubt as to whether we are dealing with hyperplastic, tuberculous, sarcomatous, or Hodgkin's nodes, the importance of the diagnosis suggests the removal of tissue for examination. In older subjects this can be done under cocain. In children one will prefer ether. Then, assuming the enlargement of but a single group of nodes,

I think it wise to proceed with the removal of all the palpable ones. They peel out so easily, as a rule, that the patient is not harmed by completing their removal, and both patient and friends are pleased by the disappearance of the tumor. Moreover, pressure symptoms are alleviated or postponed. After operation on an early case the patient may be to all appearances well for a year or more. We have seen a child improve in color, gain in strength and grow, but finally the generalized recurrence appears and the anemia or pressure symptoms terminate the case. Whether the generalization is at all delayed by the early removal of a group of nodes is not settled.

Hertzler (18) says, "We now (1911) have had a patient under observation for 3 years since the last (the fifth) operation with no signs of recurrence." This, however, is very unusual.

My most successful case is one of a boy seen at the age of 10 years. The nodes were enlarged in the left side of the neck from the mastoid to the clavicle. Those in the corresponding axilla were moderately enlarged. The parents dated the trouble from the time of a tonsillotomy 20 months before. All the enlarged nodes were removed and the wounds healed without infection but for a number of weeks the axillary wound drained large quantities of lymph. The case was clinically and microscopically Hodgkin's disease, and, moreover, the von Pirquet and guinea pig inoculation were negative for tuberculosis. Now 3 years and 4 months after operation glandular enlargements are just beginning in the neck and axilla. General health is good and the recurrence seems restricted to the original distribution of nodes. At the time of operation he weighed 76 and now 98 pounds.

After generalization has occurred, the most that is warranted by way of operation is the removal of a node for diagnosis, the doing of a tracheotomy, or the removal of nodes causing serious pressure, as, for instance, on the trachea. Before doing a tracheotomy one should be satisfied that it is the neck nodes that are really responsible for the pressure and not those of the mediastinum. An X-ray plate may clear up the question.

TUBERCULOUS CERVICAL ADENITIS

The treatment accorded to a case of tuberculous glands at the present day depends largely on the specialty of the physician first consulted. There are the hygienic, the X-ray, light therapy, vaccine, laryngological (that is, treatment directed to the portal of infection), and the surgical. The latter, moreover, comprises by no means a single method of treatment. One surgeon drains abscesses; another injects antiseptics; another excises glands unless there is an abscess; another excises both glands and abscess. Some hesitate to operate until sinuses are healed, while others largely disregard them. Differences of practice prevail as to the extent of excision necessary, that is, whether glands in the gland-bearing fascia should be removed or only the main glandular mass. While some operate as early as possible, others reserve surgery for the advanced cases. That the general practice of physicians is to procrastinate until suppuration impends is shown by the fact that we have few cases in private practice to operate on before the formation of an abscess. Children and adults are at times treated differently, the treatment of the latter being more radical. A simultaneous lung tuberculosis also influences treatment.

The neck nodes suffer from both human and bovine infection. Park divides the cases of tuberculous nodes into 3 groups : (a) cases under 5 years of age, (b) cases from 5 to 15 years of age, and (c) cases over 15 years of age. In children under 5 we find bovine tubercle about twice as common as the human; from 5 to 15, the human is twice as common as the bovine, and there were no bovine cases in persons over 15.

To quote Park (28):

> "In children the bovine type of tubercle bacillus causes a marked percentage of the cases of cervical adenitis leading to operation, temporary disablement, disfigurement, and discomfort. It causes a large percentage of the rare alimentary tuberculosis. In young children it becomes a menace to life and causes from 6 to 10 per cent. of the total fatalities from the disease."

The work of Park, however, did not show whether the prognosis is any better when the infection is bovine. In children under 2, in whom we expect the bovine type to predominate, Dowd thinks the prognosis not so good as in older children with adenitis.

It is unfortunate that we cannot differentiate the 2 varieties by means of the tuberculin test (von Pirquet), using human and bovine tuberculin. But tests with the 2 tuberculins show as a rule a simultaneous positive or negative result.

MEDICAL OR HYGIENIC TREATMENT

The medical or hygienic treatment consists in keeping the patient in the most healthful surroundings with abundance of fresh air and nourishing food, with restricted work or exercise, and perhaps the use of tonics. The purpose of it is to keep the patient in the best possible condition to fight the disease, and there can scarcely be a doubt that the cure of tubercle in the neck or elsewhere must come from the building up of body resistance.

Even if the glands are removed surgically the cure is brought about in the same way; we have but diminished the load of infection with which the patient contends rather than completely eradicated it. Every patient should, therefore, get the best of medical care whether before or after operation.

On the other hand, an exclusively medical treatment has a number of drawbacks. It requires a long time—one cannot say how long or when it has come to an end—and its result is uncertain. Moreover, the cure by nature is largely by the breaking down of nodes with abscess and sinus formation with ultimate healing and scarring. In children, as the treatment is to cover some years, the patient while doing well is very likely to contract one of the exanthemata during which the gland trouble is aggravated. In the end operation and scarring occur after a longer or shorter period of non-surgical treatment. Practically it is difficult in a city and among both the poor and those in moderate circumstances to obtain an adequate hygienic treatment, as it involves the outlay of much money and trouble. A child can rarely be removed from the surroundings in which it acquired the disease. Moreover, the usual reason for selecting this method, the wish to avoid a scar, is largely fallacious, as the nodes are always in danger of breaking down, thus forming a number of scars, each one of which is more disfiguring than an operation scar. Few cases will run their course to a successful termination without the discharging of one or more glands on the skin surface.

TUBERCULIN TREATMENT

The tuberculin treatment has had extensive use at the hands of a comparatively few men. It is difficult to say just how valuable this treatment may be, as it is rarely used alone, but usually accompanies more or less surgery and hygiene. To quote Baldwin (2):

> "A patient already poisoned and having a daily temperature of 100 degrees or over is no subject for any kind of tuberculin treatment. I mean that progressive tuberculosis, where fever, sweats, lost weight and strength are present, forms a contra-indica-

tion for the treatment. The patient already has more tuberculin of his own manufacture than he can stand. Harm is being done to-day by such treatment."

The cases then should be selected in which to use tuberculin with reference to these definite contra-indications. The milder cases free from acute exacerbations of trouble will be the most favorable for its use, and it is to be remembered that such are the most favorable cases for any line of treatment. This method may be used with hygienic measures alone, may be given a trial before operation, or may be instituted shortly after operation in case there is fear of recurrence. Hawes (17) administers the drug in weekly doses of from 1/10,000 to 20 milligrams, beginning with the former and increasing as rapidly as possible, being careful to avoid local or general reactions. The cases vary within wide limits in the size of dose tolerated. He combines this treatment with full diet, fresh air, out-door sleeping, and limitation of work. His results in 56 cases of adenitis, many of which were subjects of unsuccessful surgery, have been encouraging. Note the great range of dose, the maximum 200,000 times the minimum.

At the fifth annual conference of the "British National Association for the Prevention of Consumption and other forms of Tuberculosis" the subject of the tuberculin treatment of the disease was extensively discussed (29). Mackenzie (21) there asserted that vaccine treatment (if we except staphylococcus) is still on trial, that there are no animal experiments showing cures from animal tuberculosis by tuberculin, that after extensive use of it himself he is still uncertain as to its value and thinks it certainly less efficacious than other of our therapeutic procedures for the treatment of the disease.

Rabinowitsch announced the discovery that tuberculin in large enough doses to produce a reaction is followed by the appearance of tubercle bacilli in the blood and hence favors dissemination. Woodhead says that it has never created immunity either in man or animals to tuberculosis. While some favored its use, the only point on which all agreed is its potency for harm.

If too little of the drug is given, it is useless; if too much, it does positive harm. The treatment should, therefore, be given by those especially interested in its use and qualified by experience, and no good is likely to result (by accidentally striking the proper dose) at the hands of the occasional user of the drug.

RÖNTGEN-RAY TREATMENT

Von Mutschenbacher (24, 25), who is in favor of conservative treatment of tuberculous nodes, as is shown by the fact that he has operated on but 9 per cent. of 1,344 cases, speaks highly of the X-ray treatment, which, he says, compares favorably with surgery. It is his belief that the rays cause the disappearance of the adenoid tissue, leaving only the stroma.

Fritsch (16) has submitted 33 cases of tuberculous nodes to this treatment within a year. In only 4 of his cases was removal of a hard residual mass of nodes performed. In the absence of other tuberculous deposits in the body he considers the treatment very effectual. He sees advantages in combining 6 months of X-ray with other treatment.

In a few cases X-ray treatment has seemed to me to have made a small mass of nodes more adherent and difficult to remove.

Blaisch (4) gives his experience with tuberculous nodes in a carefully prepared article. He divides the cases into (a) hyperplastic, (b) purulent or cheesy, (c) ulcerated or fistulous. In the first group the nodes enlarge considerably after a single X-ray application, later to decrease markedly and become more discrete. Some do not entirely disappear, but remain small and hard. If one is removed and examined microscopically, there will be seen a central cheesy mass and around it a condensation of connective tissue in which there are no miliary tubercles. There is also noted a total disappearance of adenoid tissue. He says the results of the treatment are not due to a destruction of tubercle bacilli, as they have been found alive, though with diminished virulence, in the cheesy masses.

In the suppurating glands the rays can cause an absorption of the pus, but it is quicker to aspirate the pus or incise and suture and then use the X-ray.

He finds the fistulous glands the hardest to treat. The surrounding eczema at times makes the raying out of the question. In others the X-ray in diminished doses improves the granulations and hastens healing. The majority of his cases were of the hyperplastic variety and he was able to cure over 50 per cent. of his 50 cases.

HELIOTHERAPY

The work of Rollier (11, 30) has drawn attention, chiefly abroad, to the possibilities of light in the treatment of surgical tuberculosis. Rollier's sanataria at Leysin, Switzerland, are located 3,800 to 4,500 feet above the sea level. All types of surgical tuberculosis are here treated. The entire body—not alone the diseased parts—is exposed to direct sunlight, beginning with exposures of 5 minutes 3 times a day for part of the body, and increasing the application till the whole body is included, and the exposure is maintained for 3 to 5 hours. Erythema and painful burning are scrupulously avoided. Marked pigmentation seems to indicate high resistance and indicates a favorable course. This treatment, as employed by Rollier, has received enthusiastic commendation by some of the best European surgeons. In some cases neck nodes are described as spontaneously disappearing. In others the cure follows aspiration or sinus formation. "Open" tuberculosis is avoided if possible. Treatment is continued 6 months to 2 years in gland cases.

The illustrations in Rollier's articles are very striking. They show children naked on their beds upon an uninclosed porch and with a background of the snow-covered Alps. Others are seen playing on the snow in the bright sunshine and clothed only with a jock strap and a pair of skis.

At St. Mary's Hospital for Children we have always been impressed with the improvement made in hemoglobin and weight by children with tuberculous glands when sent from the hospital to its country branch. The diet is the same in the 2 institutions and improvement occurs in those who are unable to take exercise as well as in those who are; hence it seems as if the greater number of hours spent in the sunshine were the essential difference.

When a child with tuberculous glands must be treated in the city, though we cannot follow Rollier's methods in detail, yet both in institutions and in private it would seem easily possible to greatly increase the number of hours spent out of doors and to subject wounds and sinuses as well as other portions of the body usually covered to the direct sunlight through windows.

LARYNGOLOGICAL TREATMENT

It is an interesting fact that surgeons in general until very recently operated on their cases of cervical tuberculosis blissfully ignorant of the source of infection and rather persuaded that in a given case there was no way of knowing the portal of entry. Though one should always make an effort to locate the primary focus, it cannot be denied that a great many cases have been cured without locating it. As in other parts of the body with various infections, the lesion at the point of inoculation may be very small and soon heal of itself either before or after the removal of the more extensive secondary lesions.

Location of the Source of Infection.—While lymphatic drainage has very free anastomoses and different groups of nodes freely communicate with each other, yet if one can determine the first nodes to enlarge, either from the history or from the greater size or more advanced lesion of the nodes first affected, he has a very definite guide to the location of the primary lesion.

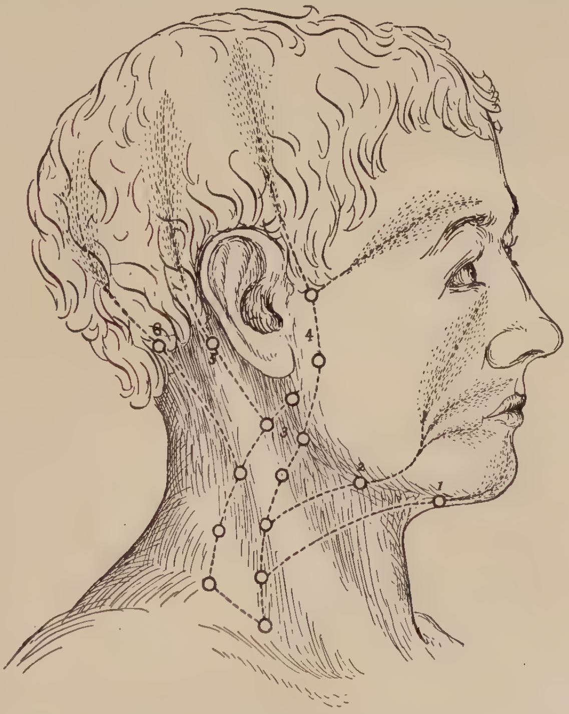


FIG. 3.—GROUPS OF NODES IN THE HIGHER PART OF THE NECK. The chief groups are numbered.

The groups of nodes in the higher cervical collar are the submental, submaxillary, carotid (or tonsillar), parotid, submastoidal and suboccipital. In children, in over 75 per cent. of cases, the carotid group, that is, that just beneath the angle of the jaw, will be found the first to enlarge. This suggests a primary lesion in the pharyngeal or faucial tonsil. We have rarely failed to find tubercle in the tonsil in such cases.

At St. Mary's Hospital for Children, Dr. H. V. Spaulding sectioned 150 consecutive adenoids and found 8 of them tuberculous. In only 1 of these was the child known previously to be tuberculous. In a few cases, but only a few, have tubercles been found in the tonsil when the corresponding neck nodes were not clinically enlarged. We are to consider that in a large percentage of cases in children the pharyngeal or faucial tonsils are the source of infection. However, I have demonstrated the focus in isolated cases on the gum, the inside of the cheek, at the suboccipital hair line, the skin of the malar region and in an adult on the skin just above the clavicle with enlargement of nodes in the episternal notch.

The present tendency is to attribute a large number of local and general infections (rheumatism, etc.) to infection through decayed teeth and gums. However this may be with other infections, it is almost negligible with regard to tuberculosis. The nodes to enlarge first are not those in most immediate lymphatic connection with the jaws (which enlarge very promptly in jaw infections), nor is a clinically recognizable tuberculous lesion, either a superficial lesion or osteomyelitis of the jaw, frequently found in patients with tuberculous glands.

Removal of Adenoids and Tonsils.—The removal of adenoids and tonsils is very frequently followed by subsidence of glandular swellings, but there is little reason to believe that even a complete removal will do more than slightly aid in the cure if the tubercle has passed from the tonsils to the nodes. In fact, a tonsillectomy may immediately accelerate the tuberculous process in the nodes.

In a child, if the glands are only questionably tuberculous, first test the reaction to tuberculin. If that is negative, proceed with the removal of the tonsils and the nodes will subside promptly. If the glands are tuberculous it is a good rule not to operate on tonsils and nodes at the same time.

I usually prefer first to remove the glands and later the tonsils. In the few cases where the adenoids and tonsils are so obstructive as to make a prolonged anesthesia difficult the reverse order may be followed.

There can be no doubt that simple infections of the tonsils of the types that produce hyperplasia of neck nodes will make it easier for a preëxisting tuberculous process to spread in the inflamed nodes. Hence diseased adenoids and tonsils should be removed in such cases as an adjuvant to the direct treatment of the tuberculous nodes. As a general proposition, attend to the nodes first and then the tonsils and adenoids, with all possible care in the checking of hemorrhage.

The tuberculous focus in the tonsil may be small and negligible, as is shown by the infrequency with which we see a clinical tuberculosis of the tonsil, especially in children; but if these tonsils are frequently the seat of inflammation of any variety, the nodes in relation to them enlarge and facilitate the spread of the tuberculous process in them. The question of the removal of tonsils and adenoids should be considered in every case of tuberculous glands in children; but their removal is determined on other grounds than that they have allowed the passage of the tubercle bacillus. In fact, if they are not obstructive and not inflamed, it is wiser not to remove them.

SURGICAL TREATMENT

Recent literature on the subject of the surgical treatment of tuberculous nodes is not particularly voluminous and seems to indicate a general lack of interest in the subject. Such articles as appear advise less radical procedures than formerly. "Injections," "incisions," "removal if breaking down threatens," and "removal of the main masses" are all methods mentioned with approval in present-day articles. The tendency seems to be to recommend only such surgery as is unavoidable. The papers of Stone (32), Dowd (12, 14), and Muller (23) are strikingly in contrast to this tendency.

When an inquiry was recently made through the *Journal of the American Medical Association* as to the best method of treatment answer was made as follows:

> "In children, tuberculous lymphadenitis tends to remain localized and to break down early to form abscesses. In this form of the disease incision of the abscess with subsequent drainage, combined with general hygienic measures, will usually effect a cure. In some cases a sinus may persist after drainage, necessitating removal of the diseased glands."

The surgical treatment, according to this advice, is to be kept as a last resort. Some of the patients whose photographs are shown have been cured by an operation lasting an hour, residence in a hospital of a week, and no other treatment. That outlined by the *Journal* may last for years. One wonders whether the same advice would be given if the glands of the groin were enlarged as an isolated tuberculous focus. And if radical surgery is to be recommended in the latter and not in the former, what condition, local or general, indicates a different method of treatment in the 2 cases. The only obvious difference is that the scar is visible in one case and concealed in the others. The question of scar is often given more weight by both physicians and parents than promptly ridding the body of a tuberculous focus. Few patients, children or adults, will be cured without suppuration and sinus formation. The result of these sinuses when multiple, as they involve a variable amount of sloughing of skin and deeper tissues, is a puckering scar and worse disfigurement than the single transverse scar of a surgical operation.

There is a widespread notion that surgical treatment is inefficient; that glands recur even at the site of a previous operation so that when operation is recommended it is to be looked upon as but the beginning of a series of operations.

The objections to surgery may be epitomized as follows:

(a) Children at least get well without it.

(b) We have no certain method of diagnosis in early cases.

(c) We cannot remove all the infected glands.

(d) Scars.

(e) Recurrences.

I wish strongly to advocate the earliest possible complete removal of an isolated glandular focus, both in children and adults, for the following reasons: The disease spreads from a point, it is local at first and can be removed without sacrificing important structures. Removal can be done with slight scarring and a comparatively short operation when done early. Hygienic treatment is always important, but will be more successful after gland removal than when tuberculous glands are present. **A child who has tuberculous glands, who has a slight temperature, is pale and run down, will improve rapidly in the weeks succeeding operation and be in much better condition to withstand the other infectious diseases of childhood which he is reasonably sure to acquire than if the glands remain. In other words, operation initiates improvement.** Early thorough operation gives excellent results as regards scar, duration of treatment, and freedom from recurrence. Our best results are in the early cases. We may not remove every tubercle bacillus or miliary tubercle from some of the smallest glands, but we do enough to accomplish a cure. The operation has a very low mortality. The reason for the discredit of surgery is to be found in half-hearted work on neglected cases. No spectacular results are to be expected by any method of treatment when the glands have become widely scattered and are broken down in a number of situations.

It may be objected that the course recommended will lead to operation in a large number of cases that prove not to be tuberculous, since there is no single sign to separate the hyperplastic from the tuberculous. While it is true that there is no infallible sign, yet the experienced surgeon will rarely be deceived even in the early cases if history, examination, and tuberculin test (von Pirquet) are all given due weight. If there is a doubt, the case is kept under observation for a month or 2, during which time the hyperplastic nodes will rarely fail to show improvement. When there are associated lung and gland tuberculosis, opinions will differ as to the advisability of removing the lymphomata. If the neck involvement is extensive and the lung tuberculosis is slight, the operation may aid in the cure of the lung lesion. Judd records 10 operations on patients with bacilli in the sputum and says that 9 of them were much improved by the operations.

(I entirely agree with these views.—Editor.)

Operation Through a Transverse Incision.—This is the operation which has been described in detail by Dowd and is the one we most frequently employ at St. Mary's Hospital for Children (Figs. 4, 5 and 6).

An incision is made through the skin following the line of a skin crease or parallel to one about 2 in. in length and not less than 3/4 in. below the jaw. The incision is carried through the platysma and fascia and over the lymph-nodes. By carrying the dissection from the incision up between the nodes and deep fascia the branch from the facial nerve supplying the triangularis menti muscle will be avoided. The dissection usually begins along the anterior margin of the nodes and is carried from there inward, freeing them as rapidly as possible from the underlying vessels. The sternomastoid is separated from the outer aspect of the nodes until the spinal accessory nerve is reached. Nodes often completely surround it and may require piecemeal removal. If the nerve is not encountered at once, where it enters the muscle, it may be identified above, where it first appears in the field of operation from beneath the digastric muscle just below the tip of the transverse process of the atlas. This point is easily felt in the depths of the wound.

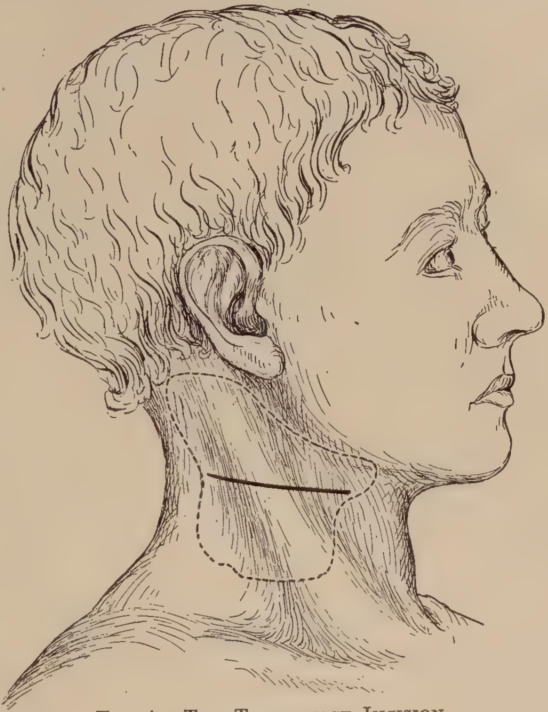


FIG. 4.—THE TRANSVERSE INCISION.

By the proper use of retractors different groups of nodes can be successively exposed and removed, the area approachable being illustrated in Figure 4. Should there be need, as when an abscess points behind the sternomastoid muscle, the incision can be extended backward across the muscle, or it may be extended forward into the submaxillary triangle. In the great majority of cases in children this incision gives adequate approach to all the enlarged glands. The removal of the most posterior ones makes a pocket of the wound behind the muscle, hence it is wise to insert a drain through a transverse stab wound behind the muscle. A rubber elastic band makes a very satisfactory drain. Drainage is usually indicated, unless the wound is unusually dry, because of the large dead space, the many interrupted lymphatics and venous oozing. The skin wound is completely sutured with subcuticular stitches, which may be of catgut or silkworm-gut. A large fluff dressing should be applied partly to exert

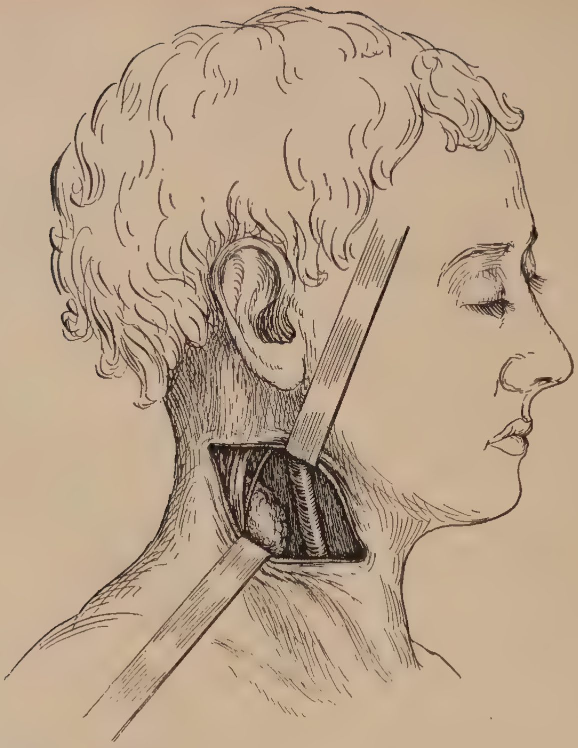


Fig. 5.—Spinal Accessory Nerve Seen Crossing the Operative Field.

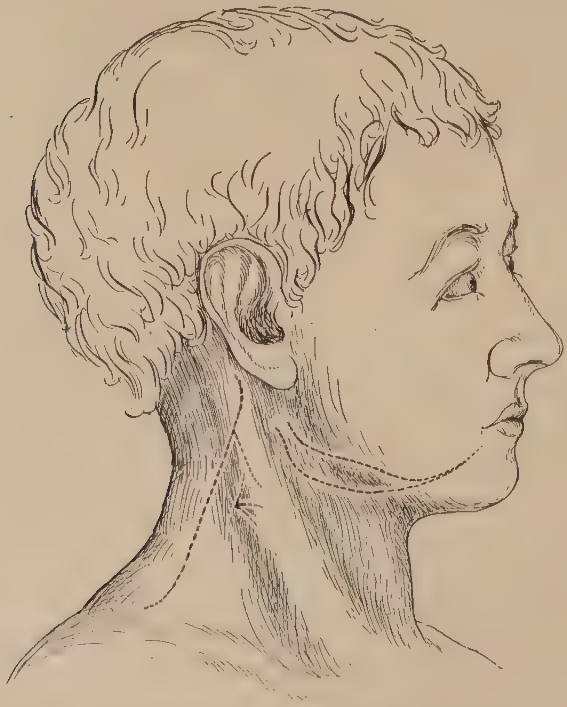


Fig. 6.—Course of Spinal Accessory Nerve and the Varying Course of the Facial Nerve Fiber to the Triangularis Menti Muscle.

pressure on and obliterate the cavity and to act as a splint to limit the motions of the head. The drain will have served its purpose in 2 days unless there is infection.

In this operation we attempt the removal of all palpably enlarged nodes. It cannot be called thorough in the sense that we use the term in speaking of cancerous nodes, but in children, with their strong tendency to recovery, experience shows that it is sufficiently radical. The outlying slightly enlarged nodes may be only hyperplastic. The resulting scar in a year will be scarcely visible and much less conspicuous than even one sinus following a broken-down node. The time spent in the hospital in the healing of the wound and the abandonment of surgical dressings is 10 days to 3 weeks in the non-infected cases. The operation will rarely last longer than 1 hour, and it will be better to postpone a dissection of the opposite side of the neck till a later date. No important structure is divided in the operation, blood loss is usually small in amount—nothing compared to an operation for adenoids and tonsils. There should be practically no mortality. There was one death at St. Mary's in 16 years which resulted from sloughing of the jugular and late secondary bleeding.

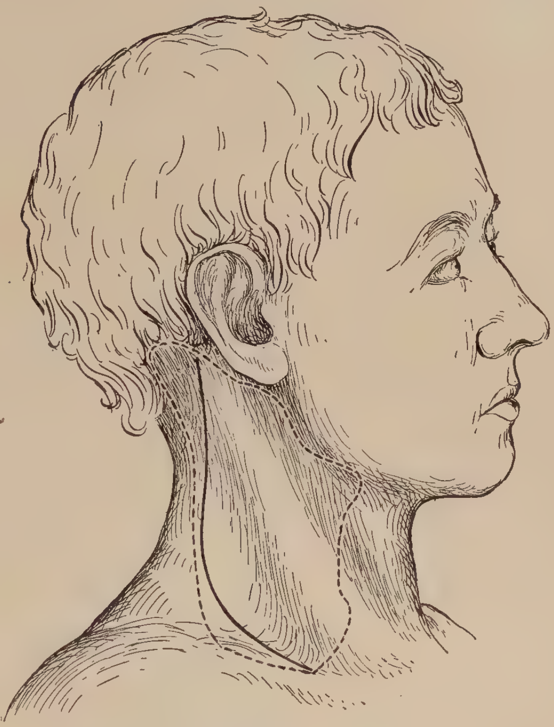


Fig. 7.—The Posterior Incision

Operation Through a Posterior Triangle Incision (Charles Mayo).—The incision may be somewhat varied in individual cases, but usually begins at the mastoid tip and runs downward in the posterior neck triangle just in front of the hair line and trapezius muscle; halfway down to the clavicle it curves forward and terminates just above the clavicle over the clavicular attachment of the sternomastoid muscle (Fig. 7). The external jugular vein may be divided or retracted forward. The skin is undermined to such an extent that the whole posterior triangle of the neck is exposed with its contained nodes. The posterior border of the sternomastoid muscle is identified and separated from the nodes beneath it. We then isolate the nerve to the trapezius muscle. It can be identified at either of 2 points. Usually one finds it either coming from or coming from under the sternomastoid muscle above its middle and about ½ in. above the sensory nerves that curve around its posterior border and spread out on the muscle (Fig. 6). If with even this guide to its location the surrounding inflammation confuses us, we may first seek the nerve at its termination in the trapezius. It enters the muscle well down toward the shoulder, and if the muscle edge is carefully followed, we cannot fail to find it entering the outer border in a region where the nodes are not likely to obscure the anatomy. The nerve, wherever identified, must be dissected free from the nodes from trapezius to sternomastoid before the dissection of the nodes is begun. The sternomastoid muscle is then dissected free from the underlying nodes for its entire length. In order to do this, the sensory nerves curving forward over its posterior border must be divided. They are not important and interfere with the retraction of the muscle. When the muscle has been freed, it may be retracted to a considerable distance, not forward, but outward, away from the underlying structures. This retraction then exposes all the nodes lying beneath the muscle and gives access to the nodes in the back part of the submaxillary triangle. The outlines of the tumor mass having now been defined, the dissection is begun from below and carried upward. A small piece of gauze may be stuffed under the lower

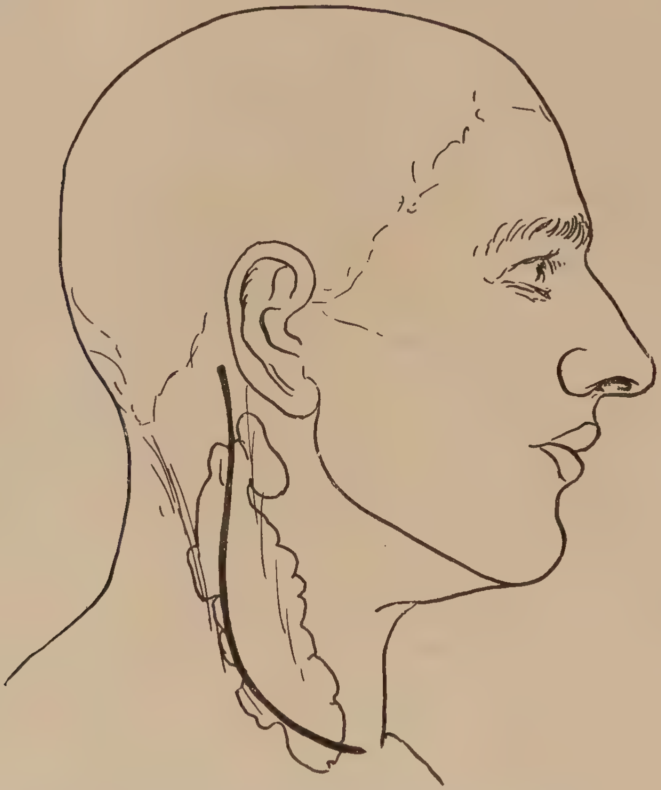


FIG. 8a.—NODES IN POSITION. Showing line of incision.

end of the sternomastoid muscle for 2 purposes, first, to prevent the entrance of air, should a wound be made in the jugular vein; and, second, to cause the veins, especially the internal jugular, to become distended, hence more plainly visible and less likely to be injured. The whole layer of node-bearing fascia with its small vessels and nerves is then dissected away from the muscles lying beneath. We should be on the lookout for and not injure the thoracic duct and phrenic nerve.

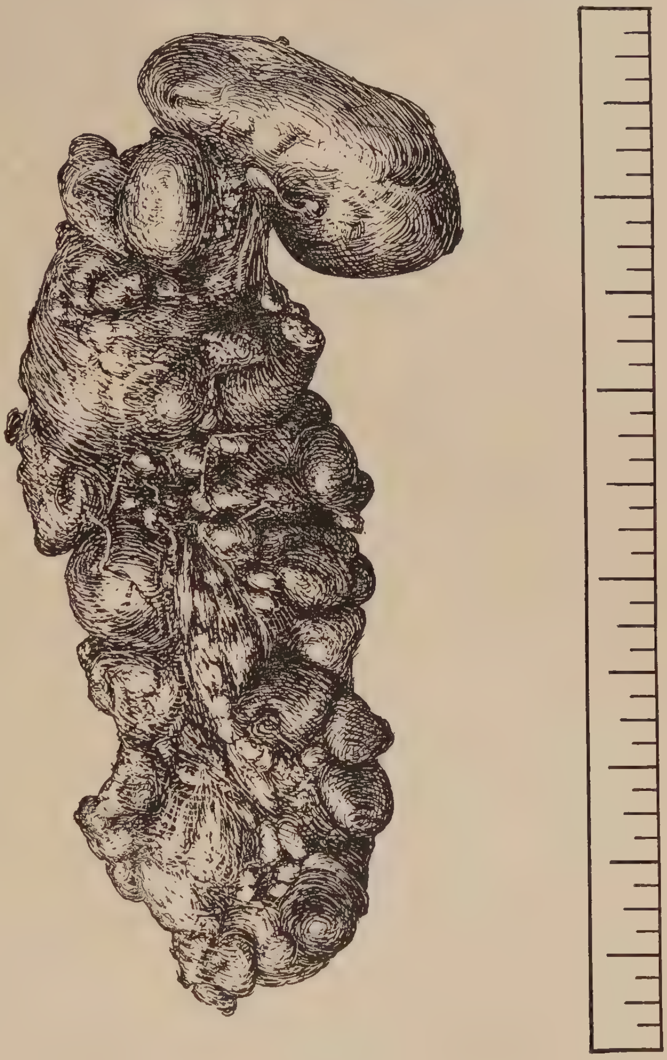


Fig. 8b.—Nodes Removed. Actual size.

When a large vein is cut, pressure with gauze should be made on the bleeding point and the vessels accurately caught but not in a mass of tissue. The dissection of the jugular is done with the vessel in plain view and preferably distended.

Its accidental injury is most likely to occur when the vessel is collapsed, and especially when from lateral traction on the node mass the vein is drawn to a distance from its normal situation. Should the separation of the vein from the nodes prove impractical, one need not fear to excise a segment of it. If a small wound is made in the side of the vein, or, what is more common, a branch (common facial) is divided close to the vein, we may repair the defect without totally obstructing the jugular. Either a lateral ligature may be applied or a lateral suture is attempted, using fine silk threaded on the smallest available needles. The nodes are removed preferably as one mass, as illustrated in Figure 8. When the nodes are removed in their fascia, there is no possibility of a recurrence in that region. Should there be nodes too far forward to be safely attempted through this incision, another one may be made to supplement it in the submaxillary triangle. The wound is sutured in 2 layers, the first bringing together the platysma and fascia and the second the skin. In the extensive dissections a drain should be inserted either in the lower angle of the wound or a stab wound may be made for the purpose at the lowest point of the dissected cavity near the clavicle and some distance behind the incision. We prefer rubber elastic bands for drainage. Rubber tubes may give rise to dangerous pressure. The purpose of a drain is to remove the blood and lymph which collect in the first few hours; hence the drain may be removed at the first dressing and left out unless there is infection. A voluminous gauze dressing is applied, which by its uniform pressure tends to check oozing and obliterate the space.

Judd (21) reports 649 cases operated on by this method. The patients were nearly all adults. The method is unnecessarily radical for most cases of tuberculous glands of children.

Operation for Tuberculous Abscess Communicating with a Tuberculous Gland.—It frequently happens that a tuberculous node at the angle of the jaw or elsewhere and lying beneath the fascia swells up and becomes distended with tuberculous pus, the node adheres to the fascia, and finally the pus in the node perforates its own capsule and the overlying fascia to form an abscess between the fascia and the skin. At first the skin is uninvolved, the abscess is not tender, and is often mistaken for a "gland" under the skin. In time, however, the skin becomes involved, the abscess ruptures, and a sinus results, often continuing for months. When it finally heals it leaves a puckered, disfiguring scar because of the sloughing of skin and underlying tissue. Other glands may follow the same course and in the event of a final cure there are numerous scars, all of a rather conspicuous type.

When a swelling is found in the course of an operation to be an abscess, many surgeons content themselves with scooping out the abscess and allowing it to heal down to a sinus, considering that both sinus and abscess contra-indicate the removal of glands. That the dissection is rendered more difficult by sinus or abscess is undoubtedly true. On the other hand, it is wiser to consider a beginning abscess an indication for immediate operation before the skin is involved.

Consider the abscess to be located in a child just behind the angle of the jaw, its commonest site. The skin incision is made transversely over the tumor and the parts are dissected away as far as possible from the abscess without breaking it. When it is opened the contents are wiped away and the opening in the depth of the abscess through the fascia into the node is demonstrated—this will often no more than admit a probe (Fig. 9). The whole abscess wall is then excised, including some of the fibers of the platysma and sternomastoid. When the inflammatory tissue has all been removed, we proceed with the dissection of the underlying glands as though there had been no abscess. In these cases the wound can be closed as in the cases without abscess, and the resulting scar will be inconspicuous. If, however, the skin has been thinned out (and the dissection of the abscess thins it still more), we may as well leave the wound open and drain, for some of the skin will slough. By the method of abscess excision rather than incision we avoid sinus formation and disfiguring scars and shorten the time of treatment at the expense only of a comparatively difficult dissection. If the abscess is very large, it is wiser not to attempt the dissection but to be content to drain the abscess and to operate later in the stage of persistent sinus. Figures 13 and 16 show results of excising nodes and abscess.

Operation Where a Sinus Leads to a Tuberculous Node.—One frequently sees the advice given not to operate for the removal of glands until all sinuses are healed. This advice, if followed, often unnecessarily prolongs the period of treatment. It is true that the sinus may be the seat of a mixed infection, but the bacterial species are not usually virulent, as the results of operation show.

After waiting until all acute inflammation subsides, we scrape away the infected tissue about the sinus as far as possible, paint the area with iodin, and with clean instruments proceed with the dissection of the sinus. As far as possible we dissect outside the sinus until we come to an infected node and remove both node and sinus together. We anticipate a mild grade of infection in such cases by inserting a drain in the wounds.

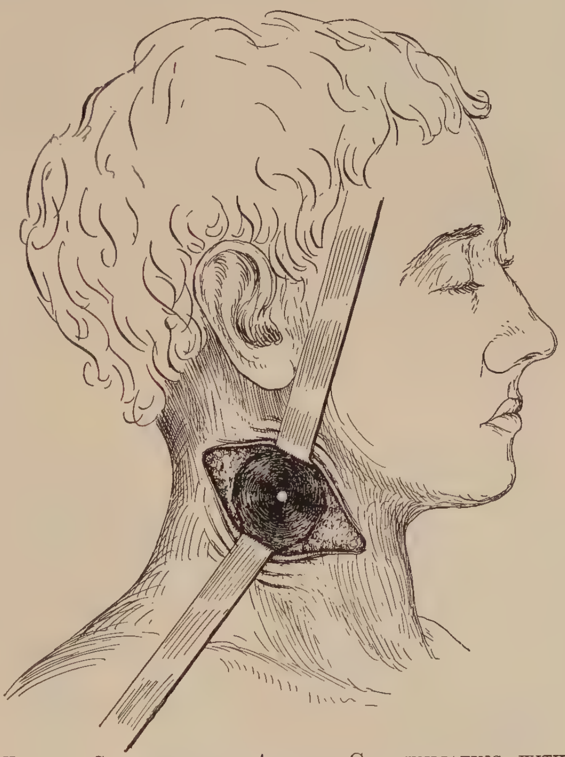


Fig. 9.—Subcutaneous Abscess Communicating with a Subfascial Tuberculous Node.

When glands have been removed thoroughly, there is usually—but not always—prompt wound healing. The soft parts may become tuberculous, the whole wound open, or the tubercle may spread in the skin. For these conditions all the antiseptic powders and ointments in the pharmacopeia have had their advocates. The favorite probably has been iodoform. Of this I make no use, its disagreeable qualities outweighing its supposed virtues. However, its virtue was assumed to lie in its iodin content, and one can use iodin locally with good effect by irrigating the wound with a weak solution of it or by applying the undiluted tincture on an applicator.

The action of sunlight has been extolled for its effect on the tubercle bacillus and tuberculous processes. One will find no more favorable field for trying it than the lupus-like condition surrounding a sinus. The dressings should be removed and the patient should be allowed to sit or lie beside a window, or, better, out of doors with his sinuses exposed to the direct rays of the sun.

Results of Operative Treatment.—The accompanying photographs illustrate some of the aspects of the operative treatment. Figures 10 and 11 show the 2 sides of a child's neck. The left side shows the inconspicuous scar of the early excision of nodes with primary wound healing. The right side is much disfigured by the scars of suppuration, one of which is above the border of the jaw and has involved the lower branch of the facial nerve with resulting disagreeable deformity of the mouth (Fig. 14). She has had no recurrence of glands in 4 years and has marvelously improved in health.

Figure 13, a photograph taken 2 years after operation, shows the result of excision of a tuberculous abscess and the accompanying nodes. The surgical care in this case occupied 10 days. The patient's weight at the time of operation was 63 pounds, three years later he is well and weighs 80 pounds. Figure 16 shows a boy operated on 2 years ago for glands with accompanying abscess. Figure 17 shows the result of operation on a boy whose nodes extended from the jaw to the clavicle. They were removed through a posterior incision, like those shown in Figure 8 b with the node-bearing fascia.

Figure 12 was taken 2 weeks after operation on a girl, and shows the transverse operation wound and also the openings of 2 sinuses that had persisted some months. Following the operation the sinuses healed promptly, leaving puckering scars.

Figure 14 shows a paralysis of half the lower lip resulting from injury to the ramus marginalis mandibulæ. During smiling the lip is drawn between the teeth, where it is frequently bitten on closing the jaws.

The man with the drooping shoulders (Fig. 15) was shown by Dr. A. S. Vosburgh before the New York Surgical Society as illustrating the bad effects that may follow division of the spinal accessory nerve. The man's neck shows the scars of several operations for tuberculous nodes and a resulting paralysis of both trapezius muscles. It is not certain that the paralysis is entirely due to the severance of the trapezius branch of this nerve, but may have been contributed to by injury to muscular branches of the cervical plexus. This man's shoulders drop forward and give him winged scapulæ and the clavicles, instead of being inclined outward and upward, have a decided downward inclination.

In the results of operative treatment we have to consider mortality, scarring, multiple operations, and ultimate cure. The selection of non-operative treatment for the prevention of a scar is based on a fallacy, as there is neither assurance nor probability that the non-operative treatment will prevent a scar or multiple scars. The early operation through an incision in the skin folds offers the best prognosis in this regard. Some of the photographs (Figs. 11-16) illustrate the inconspicuousness of the scar. In adults the scar is to be less con-

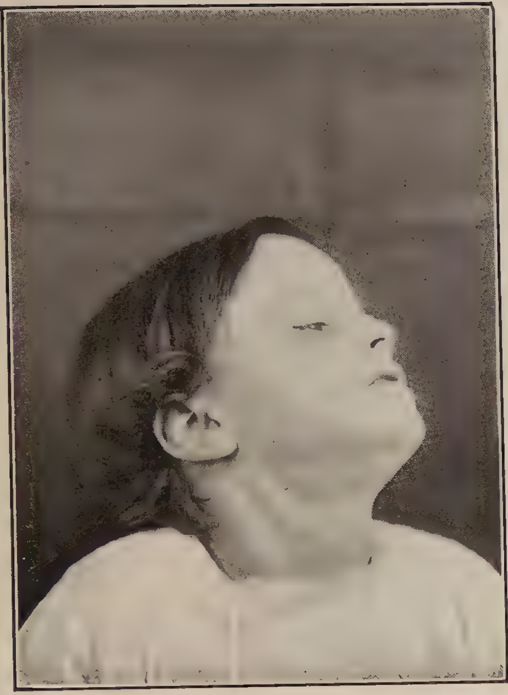


FIG. 10.—SCARS FROM SUPPURATING NODES.

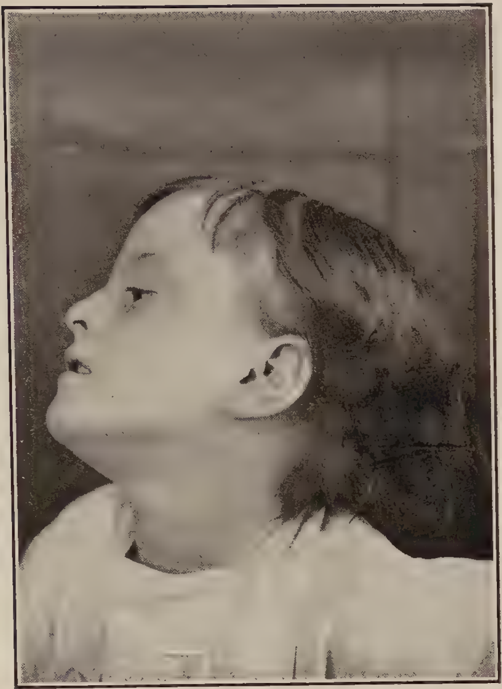


FIG. 11.—INVISIBLE SCAR. EXCISION OF GLANDS WITH PRIMARY WOUND HEALING.

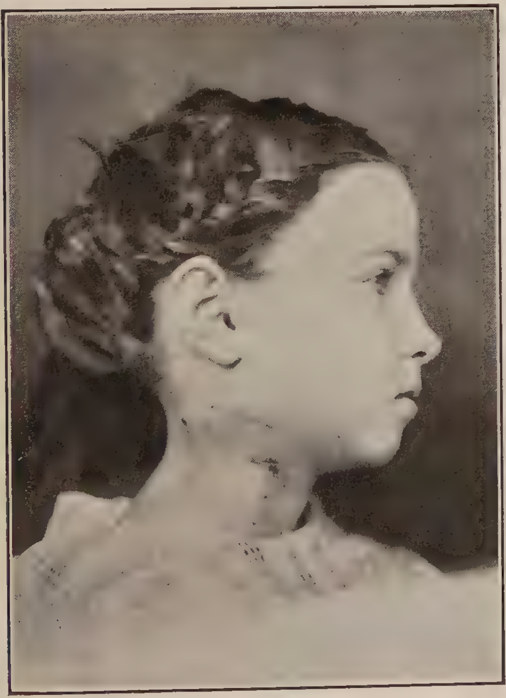


FIG. 12.—TUBERCULOUS SINUSES.

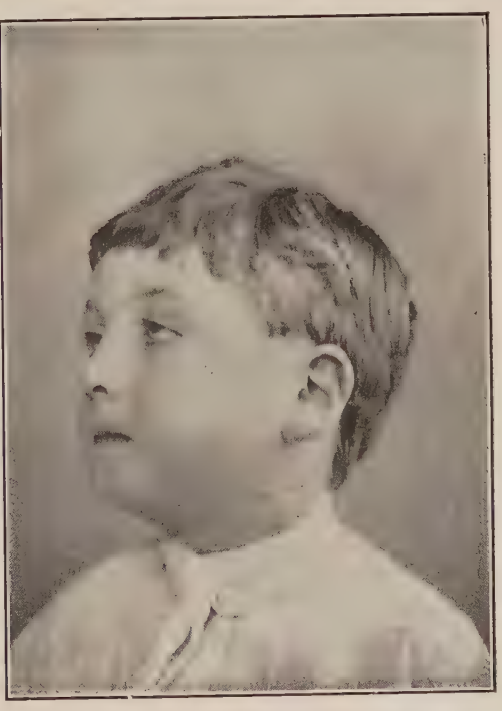


FIG. 13.—TWO YEARS AFTER GLAND AND ABSCESS EXCISION.

sidered, its importance is slight in comparison with ridding the body of its tuberculous focus in a reasonable time.

Few of what may be called major operations have as low a mortality as that for tuberculous cervical glands. Judd (21) reports no operative deaths among 649 operations, chiefly on adults. Muller from Philadelphia reports 100 operations on adults and children without mortality. At St. Mary's Hospital for Children we have had 1 death from a late secondary hemorrhage among over 500 operations on children. Dowd reports one death from embolism among 78 adults. My only operative death occurred in an adult. The operation was performed under light chloroform anesthesia and lasted 20 minutes. The mass of glands was discrete above the clavicle, and the size of one's fist. The patient developed an irregular pneumonia, presumably tuberculous, and died in a week.

Muller reports 9 recurrences among 67 adults and children. Judd reports 8.6 per cent. of recurrences among his patients—chiefly adults. Dowd reports 320 children, 2 to 17 years old, 75 per cent. of whom remained free from recurrences. An isolated easily palpable node anywhere in the neck was considered a recurrence.

Dowd thinks that 90 per cent. of children are cured by operation and with this figure I am disposed to agree. I have been able to follow to date 12 cases in children in private practice. The most recent of these was operated on over a year ago. Eight had rached the abscess stage. All are alive and apparently cured. Only 1 has required a second operation. That one had had her glands persistently poulticed and skin and muscle were extensively infiltrated with tuberculosis. A sinus persisted for some months and was re-operated on at a time when a small group of glands was removed from the other side of the neck. These children have had better food and care than the average hospital case. The results of treatment at St. Mary's Hospital for Children can be considered a very good test of the operative treatment in children for after from 2 to 4 weeks in the hospital they go back to the poverty and other bad conditions in which they acquired the disease and get no further medical treatment. Dowd has followed up these cases as far as possible for a period of 1 to 12 years and, as said before, considers that 90 per cent. are cured, approximately 75 per cent. of them as a result of a single operation.

SUMMARY OF SURGICAL TREATMENT

1. **Operative deaths in cases of cervical lymphomata are under 1 per cent.**
2. **The results of treatment—and this applies to the surgical as well as other treatment—is better in children than adults.**
3. **Surgery shortens materially the length of treatment and danger of dissemination of the disease.**
4. **Best surgical results will be obtained by complete removal of affected glands in early cases.**
5. **In children one need not dissect out the whole gland-bearing fascia but confine operation to the removal of all palpable nodes.**
6. **The operation is usually done without injury to any important anatomical structure.**
7. **Injury to the facial nerve branch supplying the triangularis menti muscle causes a disagreeable deformity of the mouth, which is probably permanent in cases where the nerve has been actually divided and not simply stretched. Division**

of the spinal accessory nerve causes a drooping of the shoulder in a portion of the cases.

8. Freedom from recurrence is the rule both in adults and children. Recurrence is the exception, but even in the recurrent cases cure usually follows a second or third operation. This applies only to thorough surgery and not to the draining of abscesses or curetting of individual nodes.

9. The operation is much less difficult before an abscess or sinus has formed. To the patient this means more complete work, a shorter operation and better chance of prompt healing with small scar and slight danger of recurrence. To the surgeon it means an easier operation in a shorter time.

CYSTS AND TUMORS OF THE NECK

1. BENIGN GROWTHS

True Tumors.—If we exclude cysts and inflammatory enlargements of the neck, we find that the true tumors are quite infrequent in this region. The most frequent of these is lipoma, located near the shoulder or just under the jaw. Fibroma is found as a skin tumor or keloid and now and then on the ligamentum nuchi.

The benign tumors rarely cause pressure symptoms (we are excluding from consideration the thyroid tumors), and are removed for their disfigurement only. Their removal is usually made through a small transverse incision, that is, one approximating very accurately the normal skin folds. The tumors are grasped by forceps and by means of blunt dissection are removed without dividing any important structures. The blunt dissection, when the incision is small, can be made by inserting the points of a closed pair of scissors into the connective tissue planes and opening them. The separation will follow normal cleavage planes and rarely injures veins. By ligature and pressure we thoroughly dry the wound, put a few buried sutures in to approximate the fascia and platysma, then suture the skin with a subcuticular stitch of fine catgut or silkworm-gut. When the wound is small, we may use sterile narrow strips of adhesive plaster instead of skin sutures. The stretching of scars is lessened by making our skin incisions as far as possible in the direction of skin creases, by bringing the subcutaneous tissues well together so that there shall be no tension on the skin edges, and by obtaining primary union.

Hygroma Colli.—This cyst or tumor, for it somewhat resembles a tumor, is found most frequently at the lower part of the neck just above the clavicle, and is in intimate relation with the veins in this region. Even the smaller ones frequently extend below the clavicle and may be very closely connected with the axillary vein. Their removal should be attempted through a generous incision, and one should make every effort to dissect them out without rupturing their walls. When once a compartment of the cyst has been evacuated the endothelial wall becomes harder to recognize. Remnants left are sure to cause recurrence

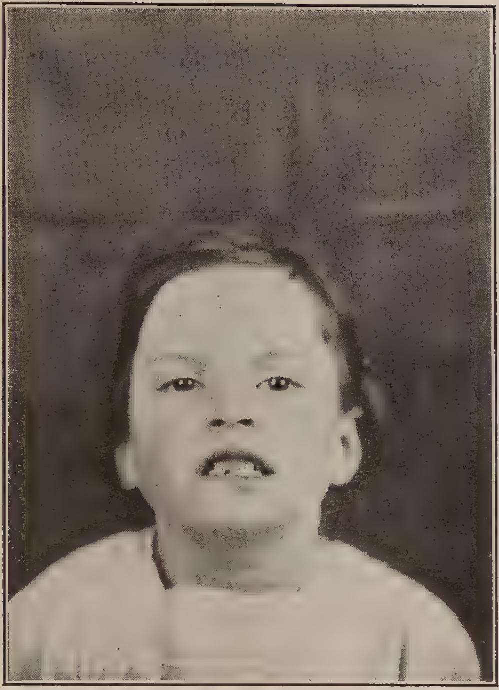


FIG. 14.—PARALYSIS OF TRIANGULARIS MENTI MUSCLE.

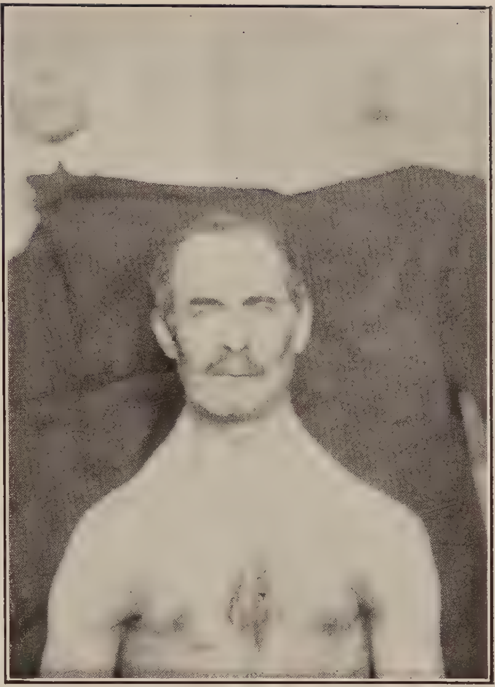


FIG. 15.—BILATERAL TRAPEZIUS PARALYSIS.

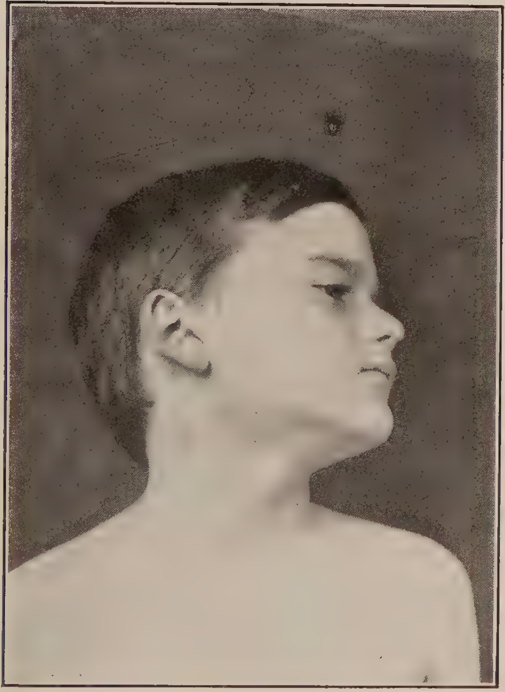


FIG. 16.—EXCISION OF TUBERCULOUS ABSCESS.

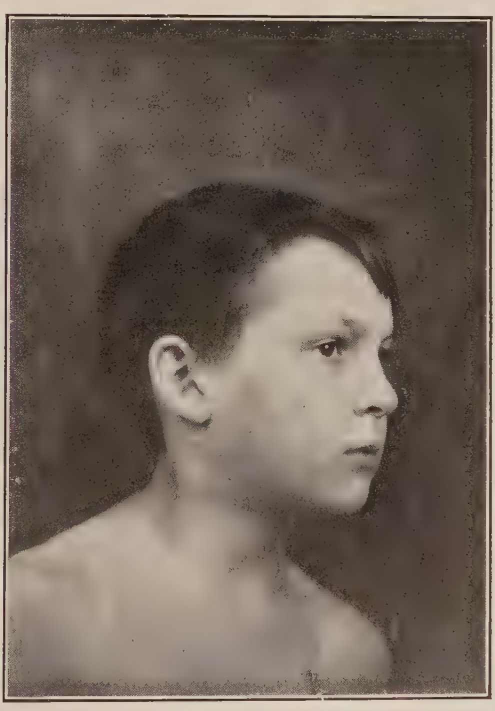


FIG. 17.—EXTENSIVE GLAND DISSECTION.

of the cyst with the certainty that the second operation will be more difficult than the first. Extensions under the clavicle may make it necessary to divide the pectoralis major. The large veins are easily injured because when flattened out over the tumor they look surprisingly like its wall.

Thyroglossal Cysts and Sinuses.—These occupy three positions: (1) Between the foramen cecum of the tongue and the hyoid bone; (2) between hyoid and larynx; (3) below the larynx lying on the trachea. The second variety is much the most common. The growths appear as cysts which approach the skin and rupture or are incised so that, as a rule, the surgeon has a sinus rather than a cyst to treat. Suppuration may complicate the operation.

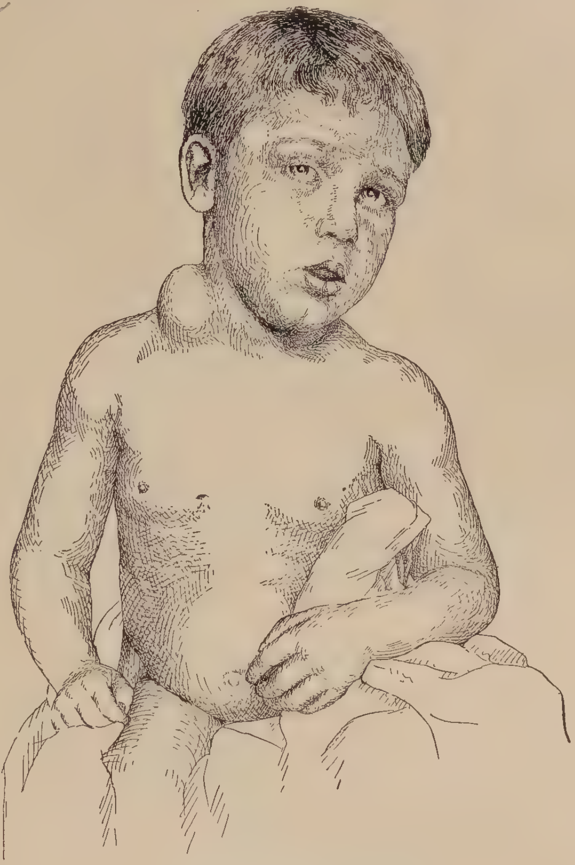


FIG. 18.—HYGROMA COLLI.

TECHNIC OF OPERATION.—If it is feared that the sinus will be hard to recognize, one may inject it with a strong solution of methyl blue or tincture of iodin, but this is not usually necessary. An incision is made preferably transversely and surrounding the scar or sinus. The edges of the sternohyoid muscles are identified and retracted. The sinus is caught and held with forceps. One follows its periphery, separating it from the surrounding fat by sharp or gentle blunt dissection, being as careful as possible not to tear the superficial from the deep portion. The sinus will be felt to run inward toward the lower edge of the hyoid bone. When that point is reached, it will be found good practice not to cut off the sinus close to the bone, but to cut away the lower border of the bone with the sinus. This is usually easy, for most of these operations are on children and the cartilaginous hyoid is easily cut. This is the only way to be sure that the very bottom of the sinus has been reached. As the sinuses are infected, it is usually best to leave a small drain in the wound.

Median cysts below the larynx and lying in the episternal notch between the thyroid lobes are exceedingly uncommon. They can be shelled out until a pedicle is reached attaching them, presumably, to the thyroid isthmus. This pedicle will have to be divided.

The cysts below the foramen cecum are called by Bland Sutton "lingual dermoids." At times they are small and lie just under the foramen cecum producing a swelling in this region. They can be incised on the back of the tongue, but excision is difficult. The larger ones push the tongue out of the mouth and can be felt between the mandible and the hyoid bone. They must be attacked from below. The incision may be in the median line, but more room will be had by making a curved incision parallel with the jaw. It may be necessary to empty the cyst to get at the deeper portions, but, if so, great care must be exercised not to leave any portion of the wall of the cyst. The firmest attachments have been found to the hyoid bone and foramen cecum.

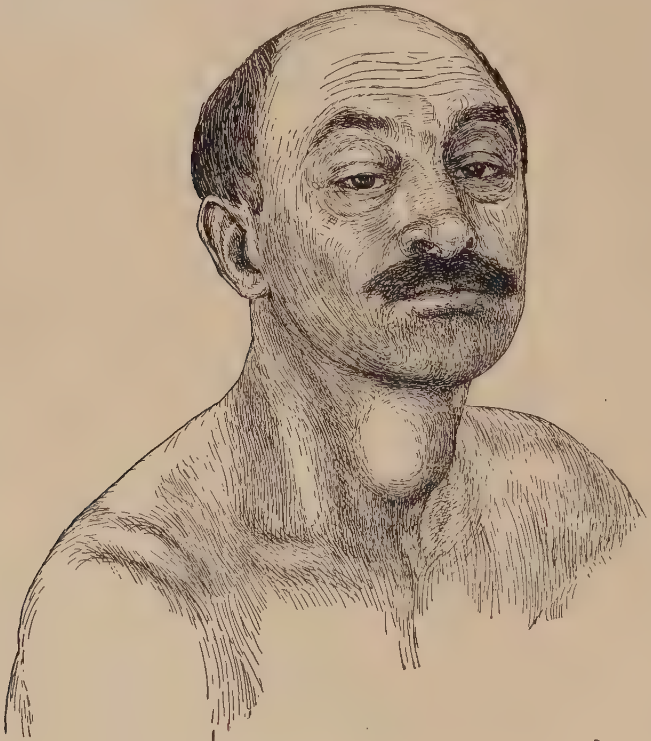


Fig. 19.—Subhyoid Thyroglossal Cyst.

Cervical Auricles: Branchial Cysts and Fistulæ.—The second, third, and fourth branchial clefts have their external orifices along the anterior margin of the sternomastoid muscle. The opening of the second, the one causing the most trouble, is at about the level of the angle of the jaw; internally it opens into the space in which the tonsil is lodged. If there is a fistula, its removal with closure of the pharyngeal opening will tax the resources of the most careful dissector. The tract has been usually described as passing into the pharynx between the external and internal carotid arteries. The third and fourth clefts enter the upper part of the larynx and their removal is attended with the greatest danger to the superior laryngeal nerve. The cysts of the second cleft are comparatively common and are difficult to distinguish from a node in the same situation, for their wall is thick, being composed of fibrous, lymphoid, and epithelial coats. Their operative removal does not differ from the operation for a tuberculous lymph-node.

The branchial sinuses opening externally are often but slightly disfiguring, and had then better be left alone, for the scar of operation will be more noticeable than the small skin depression representing the branchial cleft. Tabs of skin and cartilage (called cervical auricles) are rarely seen in the neck, but are frequently seen as "accessory auricles" just in front of the ear. They offer no surgical difficulties except when associated with sinuses.

CASE.—A woman was operated on 6 years ago for a cystic swelling beneath the ear. A sinus resulted. At a second operation an unsuccessful effort was made to excise the sinus. The facial nerve was injured and sutured. A sinus again remained which in the past 6 years has never discharged much and has occasionally healed. At the third operation the sinus was easily followed and led to a mass lying between the cartilaginous auditory canal and the mandible. On removal it was found to be composed of cartilage lined with skin and presumably represented an accessory auricle; indeed, it much resembled the concha of an ear.

Tumor of the Carotid Body.—This rare tumor presents unusual difficulties to the surgeon, and should one encounter it without having suspected the diagnosis the experience will not soon be forgotten. So many have now been described and the symptoms are so characteristic that one should at least have its possibility in mind when one or more of its features are presented by a patient. The tumor originates at the carotid bifurcation and tends to grow upward

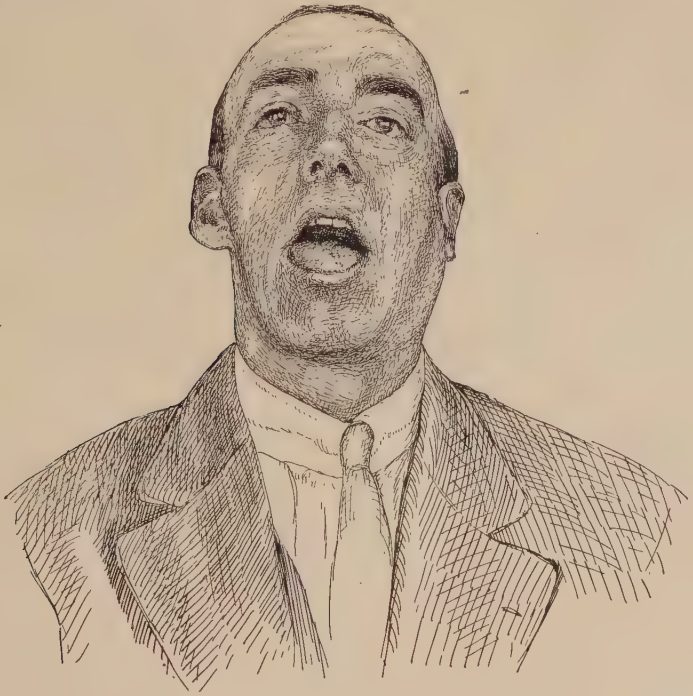


FIG. 20.—TUMOR OF THE CAROTID BODY. Note hemiatrophy of the tongue.

toward the base of the skull. As it originates in the carotid sheath the pneumogastric, hypoglossal, and sympathetic nerves suffer early. Unlike tumors of lymph-nodes in the same region, it tends to displace the pharyngeal wall inward. These tumors are so vascular that a bruit and expansile pulsation have led to their being mistaken for aneurysm. The difficulties of operation are in no way commensurate with the size of the growth.

The incision should be a long one at the anterior border of the sternomastoid. As soon as the tumor is exposed, an effort should be made to determine its operability before such profuse bleeding is encountered that one cannot abandon the operation without ligation of the carotid. In most of the cases all 3 carotids have required ligation. The common is ligated first, then the external, and finally the internal, at the base of the skull, though one will be fortunate if the growth has not extended along this so far that there is no room for ligation of the vessel above the growth. The ligation of the carotid has such a high mortality that one would hesitate to do it except in the young.

The dangers of the operation are (1) an immediate mortality of 25 per cent. (DaCosta, 9); (2) softening, hemiplegia, etc., from carotid ligation; (3) injury to the hypoglossal, pneumogastric, and sympathetic nerves.

In my case (Fig. 20), though the tumor was not large, the operation was abandoned when it was found that the pharyngeal wall (with tonsil), the abovementioned nerves, all the carotids, and the internal jugular vein would have been sacrificed in removing the tumor. The patient is now (2½ years later) fairly well and able to work, though suffering from slight neuralgia. The growth has increased about ⅓ in size.

In the young, when the tumor is small, radical extirpation should be attempted; in older patients, especially when vessels are atheromatous, rendering carotid ligation dangerous, it will be wiser not to operate. The tumors may grow slowly for years, but ultimately will assume malignant characters. In the patient shown in Figure 20 the pupils are unequal, the left side of the tongue paralyzed and atrophic, and the voice is impaired by recurrent laryngeal paralysis. There is a bruit like an aneurysm over the tumor which is due to the nature of the tumor and not simply transmitted from the carotid, as was shown in Lilienthal's case, where an expansible pulsation and bruit were present in a recurrent tumor, though all the carotids had been removed at the original operation.

2. MALIGNANT TUMORS OF THE NECK

In the neck malignant disease finds one of its favorite seats. It occurs usually as an epithelioma of the soft parts, and especially of lymphatic structures. We see it chiefly in 3 locations.

A. Growths beginning in the submaxillary region and constituting the lymphatic extension from growths primary in lips, tongue and jaws.

B. Growths appearing primary in the neck. It is not unusual to find a carcinomatous mass beneath the sternomastoid and infiltrating it, with no primary

growth on skin or mucosa. Some of these growths give microscopic evidence of a branchial origin. They are usually at the level of the larynx.

C. Growths above the clavicle, first, as an extension from the axilla and, second, as metastases from the stomach and esophagus.

Malignant disease in this region presents some special features. The time of involvement of nodes of the neck secondary to primary growths on the head varies much with the kind of growth and location of the focus. While rodent ulcer about the nose, eye, and temple is usually very slow to extend by the lymphatics, that of the mucous membranes around the mouth and of the skin of the lower face is quite rapid. One should assume that the submaxillary nodes are already involved, even where they are not enlarged in these cases. We are constantly seeing patients with carcinoma in one or both sides of the neck with no epithelioma apparent, but who, on being questioned about a scar of the lip, tell us of a "wart" or "ulcer" of the lip that was "cured" a year or 2 before by caustics. These patients often appear quite skeptical when told that the two conditions are related. When an epithelioma (basal-celled carcinoma) at the side of the nose is successfully treated by radium, X-ray, caustic, or local excision, the inexperienced are prone to extend such treatment to the more highly malignant growths of the lip.

We are encouraged to attempt quite extensive excisions in the neck in these cases because, as emphasized by Crile, we have not to fear generalization of the growth, but only local extension. For example, the malignant adamantinoma, while locally destructive and extending below the jaw, has in only 1 case been described as producing distant metastases.

When we remove a growth of the face, it is not usually necessary to remove the lymphatics extending from the region of the growth to the first involved nodes. Experience shows that the recurrence takes place at the site of the original growth or in the lymph-node area, but not in the soft parts between, except rarely.

In the removal of these metastatic cancers of the upper neck, as has been emphasized by Crile (7, 8), the operation in each case should be modified according to the needs of the particular case and should not be made to adhere closely to the steps of an operation as described by any one.

Before describing the operative details, we may call attention to some of the structures which at times are involved in the growth, but which we are tempted to spare at operation.

The external jugular vein can be removed without any sequelæ, even if the internal jugular also has to be sacrificed. The internal jugular is at times so incorporated in the cancerous mass that its removal is necessary. Time will be saved by ligating it promptly above and below and proceeding with its removal with the tumor rather than attempting to separate them when adherent. The external carotid artery can be ligated with impunity whether it is involved in the tumor or only ligated to control bleeding. The same cannot be said of the internal or common carotid. The ligation of the common carotid has a 20 per cent. mortality, and softening and paralysis may result even if death does not. Cancers which cannot be removed without ligating the common carotid had better be classed as inoperable.

The division of the hypoglossal and spinal accessory nerves need give no concern. This cannot be said of the pneumogastric. As to the seriousness of its removal opinions differ. When the nerve is infiltrated with cancer it may be presumed that its function is already in abeyance and, as in one of my cases, no symptoms, either immediate or remote, may follow its extirpation. In such cases there is sure to be a paralysis of the vocal cord before operation. When not previously involved it would seem that division of both superior and inferior laryngeal nerves would surely predispose to an inspiration pneumonia. The division of the cervical sympathetic has certain immediate effects on the circulation in the corresponding side of the head and on the pupil. The circulatory effects are not serious or permanent.

Operation for Tumor of the Submental Region.—Tumors of the middle of the lower lip call for cleaning out of this section of the neck. Judd describes an operation as follows:

An incision is made parallel to the lower border of the mandible and 1½ inches below it extending from one sternomastoid muscle to the other. When the superficial tissues are undermined and the edges of the wound retracted the submental and anterior submaxillary regions are exposed, the dissection of the fascia with its contained glands begins below at the hyoid bone and extends upward. The submaxillary salivary glands should be removed in all such dissections because they are too intimately related to the infected nodes to justify leaving them. As one approaches the jaw he should be sure to make his division of tissues well above the infected nodes, if necessary, removing the periosteum of the jaw with the mass. Should it be necessary to make the operation more extensive, an additional incision may be made from one end of the foregoing incision along the anterior border of the sternomastoid, but this incision is recommended only as giving a good approach to both submental regions.

Operation for Carcinoma Below or Adherent to the Lower Border of the Mandible.—An incision should be made which will give a good exposure of the parts concerned. Butlin's incision follows the line of the sternomastoid and has another at right angles to it extending forward to the chin. Kocher's incision followed the line of the anterior belly of the digastric from the chin to the hyoid, then extended along the hyoid bone, thence upward to the ear along the sternomastoid. When a sufficient incision has been made, the skin should first be freed from the outer surface of the underlying tissues up to and slightly above the border of the jaw. The whole outer surface of the parts to be removed should now be entirely in view. We are now to excavate the submaxillary triangle of all contained areolar tissue in which fat, nodes, and submaxillary salivary gland are imbedded. The dissection is usually begun below, well below any enlarged glands, and carried from there upward, leaving the muscular floor of the space cleared of all connective tissues. As the dissection proceeds, the mass is turned outward and the dissection carried up under the jaw. The facial and lingual arteries are usually ligated, the former a second time when it crosses the jaw. The common facial vein will also be ligated. The submaxillary salivary duct is drawn out and ligated as near the mouth as possible. The last part of the dissection is that of the mass from the jaw. Cancerous nodes may lie between the salivary gland and the jaw, being firmly glued to the periosteum. If there is a suspicion of involvement, remove the platysma and the periosteum of the mandible with the mass or chisel away the lower border of the bone. The skin wound is sutured except at its lowest angle, where a small drain is inserted.

The More Extensive "Block Dissection" as Practiced by Crile.—This is applicable to cancer in the upper part of the neck secondary to cancer in the mouth, and especially to those carcinomas originating from branchial rests in the substance of the neck. The deaths from such cancers result from local destruction and ulceration of the growth, but not from distant metastases.

The operation removes the whole lymph-node-bearing fascia from the clavicle to the mandible. At the beginning of the operation the sternomastoid muscle is divided at its clavicular attachment, also the external jugular vein. Then the internal jugular is ligated and divided. The dissection is carried backward to the trapezius, and the whole fascia is lifted away from the deep muscles of the neck, working from below upward. The phrenic nerve should not be injured. The pneumogastric nerve is spared if not actually infiltrated. The carotids are not involved until the disease is advanced. The whole sternomastoid muscle is removed, but the patient is able subsequently to raise his shoulder by means of the levator anguli scapulæ and the trapezius, which may retain part of its nerve supply.

In dealing with extensive cancer of the neck, considerable experience is needed to decide what cases are operable. When one begins the dissection, he should try to avoid getting into a position from which he cannot recede when he discovers the unwisdom of the operation. For this reason it is well, as soon as one has exposed the mass, to start to free it at once in the most difficult part, namely, along the carotid. If he finds the growth too fixed or infiltrating he may stop and sew up the wound. If, however, the growth is isolated everywhere else and the deep surface of the growth left until the last, he cannot recede because the whole mass would slough if it were allowed to remain. Nothing is gained and something lost by incomplete surgery, for we hasten the stage of the open ulcerating wound.

Carcinoma in the Supraclavicular Region.—In supraclavicular carcinoma secondary to growths in the stomach or chest nothing is gained by operation. In the case of growths secondary to carcinoma of the breast and extending through the axilla opinions will differ as to the wisdom of operating. Most surgeons, at times at least, extend their breast operation up into the neck and remove supraclavicular tissue. Halstead says that he has never known of a case where the supraclavicular glands are infected being permanently cured. At best, then, the operation must be considered only palliative.

In the patient shown in Figure 21 with a carcinoma above the left clavicle no primary growth was apparent, but we would suspect a cancer of the esophagus or cardia. In another patient, who complained for some months of pain in the lumbar spine, no diagnosis was made until there appeared above the clavicle a tumor which proved to be a hypernephroma.

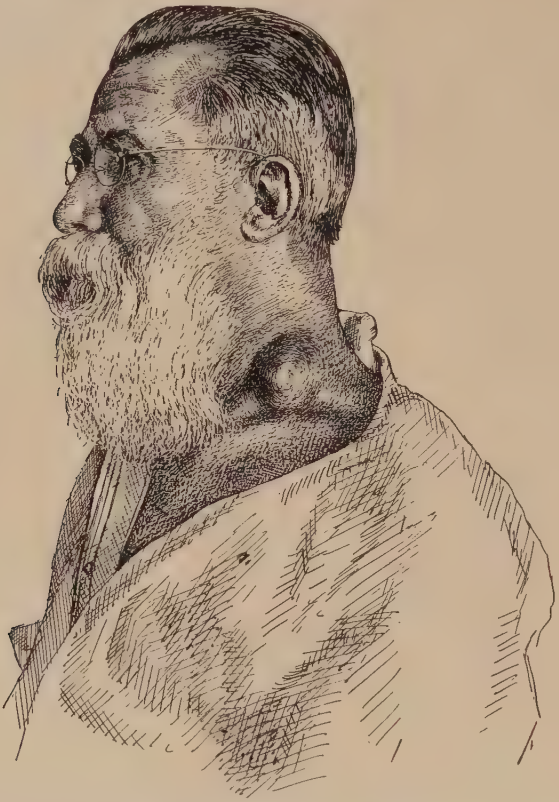


FIG. 21.—CARCINOMA SUGGESTING MEDIASTINAL OR ESOPHAGEAL PRIMARY TUMOR.

CERVICAL RIBS

The X-ray has added greatly to our knowledge of cervical ribs. They are found in both sexes and are either unilateral or bilateral. When bilateral, they usually differ in size and length on the 2 sides. Their surgical importance arises from (1) pressure on the subclavian artery producing atrophy of the fingers and arm, (2) pressure on the brachial plexus giving rise to pain and trophic disturbances, (3) the tendency to high scoliosis, resembling wry-neck, (4) association with tuberculosis of the corresponding apex. The artery alone is compressed between the accessory rib and scalenus anticus, but never the subclavian vein, which lies in front of the muscle. There result atrophy and weak pulse, but never swelling of the arm. The association of a tuberculous apex with a cervical rib has been frequently noted and has been explained in 2 ways: (1) Tuberculosis of the apex calls attention to this region with the accidental discovery of a rib which is not giving symptoms; (2) tuberculosis of such an apex is favored by the rib's agency in restricting motion on that side. It is only when symptoms are produced that the anomaly calls for treatment, and this is probably in a small but uncertain percentage of cases. Individual judgment will vary as to how much interference with form or function of the arm call for operation. Patients learn to limit the pressure somewhat by elevating the arm or shoulder. The symptoms rarely appear before puberty, but do, as a rule, appear soon after. I have seen a torticollis from a cervical rib in a child of 10.

The dangers of operation are: (a) Injury to the pleura—this has occurred a number of times; (b) the brachial plexus is always exposed to trauma, and even where its nerves are not interrupted a disagreeable temporary paresis may result from pressure or stretching. The results have usually been satisfactory in producing permanent relief of brachial and subclavian pressure, though the operation is not always easy.

Technic of Operation.—The skin incision should be large enough to give easy access to the operative field. A transverse one parallel to the clavicle will answer, or an up-and-down one over the brachial cords parallel to the trapezius border. McKenna recommends making a flap attached above and with margins along the trapezius muscle, the border of the clavicle and the posterior border of the sternocleidomastoid. This is certainly not essential, as the loose skin of the region can be readily retracted in any direction. The operation may be limited to biting away the portion of bone immediately under the vessel and nerves with rongeurs, leaving the ends in place. It is probably better judgment to make a clean dissection, removing both rib and periosteum and dividing any muscular attachments (as of the scalenus anticus), and also the thick cartilage which usually binds it to the first dorsal rib. All the attachments should be carefully divided with knife or scissors and the vessels and nerves should be kept away by the gentlest retraction. The subperiosteal operation would be easier, but bone may reform and the recurrence of pressure signs has been recorded, which might be thus explained. McKenna thinks it important that the denuded area on the upper surface of the first rib should not come in contact with the vessel and nerves; hence he frees a slip of scalenus medius, leaving it attached at its lower end, and tucks it between the vessel and rib.

Bankart (3) has removed a cervical rib by attacking it at its posterior attachment. His incision is vertical, 1 in. lateral to the vertebral spines, is 4 in. long, and has its mid point at the level of the vertebra prominens. He divides the trapezius muscles and then divides the rib at the tip of the transverse process. He then grasps the rib and divides its attachments, working from behind forward. This might not be easy were there a strong anterior attachment to the first dorsal rib.

WRY-NECK

The importance of this condition varies with the variety. Just as some persons stoop or shrug a shoulder, others tilt the head to one side purely as a matter of habit. Some cases are due to cicatricial contraction, while others may depend on paralysis of some muscles rather than contraction of others. Leaving these cases aside, we may, for the purpose of treatment, divide the more usual ones into 2 groups, the acute and the congenital, or the painful and painless.

Acute Cases.—The acute cases, commonest in the young, accompany a great variety of inflammatory diseases. The common "stiff neck," analogous to the lumbago of the lumbar spine, needs only temporary protection and treatment for the pain. If there are inflamed nodes or inflammatory infiltration of muscle planes, we treat the causative factor. In others the anatomical basis is not very obvious and the pain may persist for some time. In 2 such cases following measles and a discharging ear the pain on straightening was located over the convexity of the bent spine on the side of the discharging ear and on the opposite side to the contracted muscles. Such cases should be treated for the deformity before it becomes fixed. A plaster collar may be of service, or, as in the cases just mentioned, considerable relief to pain and a gradual straightening out of the deformity may be accomplished by means of a pulley and weight attached to the head of the bed and then to a suspension apparatus under the chin and occiput.

Congenital and Painless Cases.—Congenital wry-neck may not be noticed until long after birth. The chief contracting band is the clavicular or sternal portion, usually the latter, of the sternomastoid. If the clavicular portion is at fault, the deformity may be obscured, as the head can be brought straight by elevating the shoulder.

Operation is never to be considered as the entire treatment. The longer the duration of the case the more will habit and modified form of both bony and soft parts tend to confirm the malposition. Indeed, it is said that the condition can be cured by repeated manipulation alone if begun in infancy.

Most cases require operation, of which there are several kinds:

1. SUBCUTANEOUS TENOTOMY.—This procedure is mentioned only to be condemned because it is the most dangerous and the least efficient of the methods.

2. MYOMECTOMY (MIKULICZ OPERATION).—In this operation, through a low transverse incision, the sternomastoid muscle is divided at its clavicular and sternal attachment. The muscle is dissected upward and removed, leaving enough above so that the spinal accessory nerve will not be damaged. The same care in after-treatment is necessary as with the following method. Removal of the muscle gives an unnecessary disfigurement.

3. OPEN MYOTOMY AND FASCIOTOMY.—The incision is most conveniently made transversely and only a finger's breadth above the clavicle. The muscle

is divided transversely and, to protect deeper structures, the division may be made over a director inserted under the muscle. Both heads will usually need division, even if only one is the seat of cicatrization, for it is important to be able to over-correct. When the muscle is divided and the head tilted to the opposite side, one band of fascia after another springs into prominence and is divided with knife or scissors. The wound should be closed without drainage. A general anesthetic will be needed in children, but in adults local anesthesia has the advantage of allowing the patient to throw his head voluntarily into the position that puts the fascia on the stretch so that no band is likely to escape the operator.

4. MUSCLE LENGTHENING.—This may be done in a variety of ways. A transverse incision will answer, for the skin can be retracted upward or downward. The muscle may be split between the sternal and clavicular attachments. The former is divided high and the latter close to the clavicle; after dividing the fascia the long ends of the muscle are sutured together.

AFTER-TREATMENT.—When the wound has been dressed a plaster-of-Paris splint is applied to hold the head in an over-corrected position. The chin is rotated to the right if the right sternomastoid has been divided and then the head is flexed toward the left shoulder. The plaster includes the upper thorax and neck and runs up on the back of the neck and surrounds the head, that is, the body from the diaphragm up is inclosed except the arms and the face. This splint should be kept on not only until the wound is firmly healed, but until soreness disappears in the operation region. After its removal, active and passive movements must be continued for a variable period depending on the degree of deformity and the coöperation of the patient. Even the asymmetry of face lessens in time.

It must be remembered, however, that both bones and soft parts are misshapen and it is inconceivable that a cure in the late cases can be complete until the lapse of time has allowed the bones to become re-shaped in accordance with Wolff's law. If the division of the contracting band completes the treatment instead of beginning it, the patient's postural habit may not be changed and hence the bones will not have their normal form restored, for they are not subjected to any change in pressure.

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ESOPHAGOSCOPY AND GASTROSCOPY INCLUDING INTRA-ESOPHAGEAL METHODS OF TREATMENT

CHAPTER X

ESOPHAGOSCOPY AND GASTROSCOPY INCLUDING INTRA-ESOPHAGEAL METHODS OF TREATMENT

HENRY H. JANEWAY

ANATOMICAL CONSIDERATIONS

Before discussing the objective examination of the esophagus and stomach, a consideration of the more important anatomical facts relative to the position and size of the normal esophagus and stomach is desirable.

Position.—All clinicians and anatomists agree that the beginning of the esophagus is in the horizontal plane of the upper border of the cricoid cartilage. The relation of this plane to the vertebræ, when the body is in an erect position, differs much with age, with the degree of extension or flexion of the head, and, to some degree, with the individual. In adults, when the head is in the normal position, midway between flexion and extension, the upper border of the cricoid cartilage corresponds to the upper portion of the body of the sixth cervical vertebra. In extreme flexion, it is depressed to the level of the seventh cervical vertebra; and in extreme extension it is raised to the level of the fourth cervical vertebra. In infants, the position of the cricoid cartilage in relation to the vertebræ is much higher than in adults, corresponding, in the normal position of the head, to the intervertebral disk between the third and fourth cervical vertebræ.

The lower 1 to 1.5 cm. of the esophagus is intra-abdominal. It terminates by abrupt transition into the stomach. The left wall of the esophagus is separated from the greater curvature of the stomach by a furrow running anteroposteriorly, the walls of the 2 organs meeting at an angle of 90°. The right esophageal wall is not sharply separated from the lesser curvature of the stomach, but passes insensibly into the latter without the intervention of any angle or groove.

The relation of the lower extremity of the esophagus to the vertebræ also differs with individuals and with age and with the degree of flexion or extension of the spine, but much less in this last particular than its upper extremity.

In infants, the position of the cardia is at the level of the eighth dorsal vertebra. In a frozen subject of 76 years, Menhert found that the cardiac level was in the plane of the twelfth dorsal vertebra. The position of the cardiac orifice may occupy a higher or a lower level in the same individual, according to the movements of the diaphragm or the degree of fullness of the stomach and, therefore, according to its weight. It has been alleged that these conditions may cause the cardiac orifice to rise and fall as much as 5 to 6 cm., or through the space occupied by 2 or 3 vertebræ. I, however, believe that so great a mobility does not occur in the normal human being. It may be possible in certain patients with the more severe degrees of enteroptosis, but from experience in esophagoscopy and direct observations within the opened chest, a vertical displacement of more than 1 in. (2½ cm.) is unusual.

It may be accepted, therefore, that in infants the esophagus extends from the interval between the third and fourth cervical to the level of the eighth dorsal vertebra, and that the levels of both its beginning and termination become gradually lower with advancing years until, in the adult, it extends from the sixth cervical to the tenth or twelfth dorsal vertebra. It is convenient, in estimating the site of a new growth, to locate the termination of the esophagus in relation to the anterior chest wall. In general, it is directly posterior to a point a little to the left of the xiphoid cartilage.

Length.—Many statistics on the total length of the esophagus—i. e., from the upper border of the cricoid to its transition into the stomach—have been collected. Eleven different authors give it a length varying between 21.6 and 28 cm. The average length, and the one most frequently met with, is 24 to 25 cm. in the male, and 23 to 24 cm. in the female. It usually measures a little longer in the tall and a little less in the short individuals. The extremes of its length in the male may be said to be 21 and 30 cm., and in the female, 20 and 27 cm. Its length is not, however, exactly proportional to the body length, as will be evident from the table which follows, but in general its length is 15 per cent. of the body length.

Von Hacker has compiled the following table, which gives not only the length of the esophagus itself but also the length of its various portions and the distance from the incisor teeth to the beginning of the esophagus.

Thirty-eight measurements were made upon *men* of whom
2 possessed a body length of 156-160 cm. and esophagus of 23-26 cm.
19 " " " " " 160-170 " " " " 21-27 "
17 " " " " " 170-176 " " " " 22-30 "

Upon *women*, there were 22 measurements:
6 possessed a body length of 148-150 cm. and esophagus of 20-24.5 cm.
12 " " " " " 150-160 " " " " 27 "
4 " " " " " 160-166 " " " " 25 "

The following table summarizes the distance from the teeth to the 3 normal constrictions of the esophagus and, therefore, the length of its different portions:

	Variations	Average	Most Frequent Distance
Men			
Distance from teeth to beginning	14–16	14.9	15 cm.
Distance from teeth to bifurcation	23–29	26	26 cm.
Distance from teeth to cardia	36–50	39.9	40 and 41 cm.
Women			
Distance from teeth to beginning	12–15	13.9	14 cm.
Distance from teeth to bifurcation	22–27	23.9	24 cm.
Distance from teeth to cardia	32–41	37.3	38 and 39 cm.

It is important also to be familiar with the variations in the length of the esophagus and of its various subdivisions in children. The following table, also from von Hacker, supplies this information:

Age	Distance from Incisor Teeth to			Length of Whole Esophagus	Length of Supra-bifurcation Portion	Length of Infra-bifurcation Portion
	Lower Border of Cricoid	Bifurcation	Cardia			
	cm.	cm.	cm.	cm.	cm.	cm.
9 days	7	12	17	10	5	5
3½ months	8	13	20	12	5	7
14 “	10	14	22	12	4	8
21 “	10	15	23	13	5	8
2 years	....	....	....	13.5	5	8.5
3 “	....	....	....	14	6	8
4 “	....	....	....	15	6	9
5 “	10	17	26	16	7	9
6 “	11	19	28	17	8	9
9 “	....	....	....	16	7	9
11 “	10	18	28	18	8	10
12 “	10	18	28	18	8	10
14 “	11	19	31	20	8	12
15 “	14	23	33	19	9	10

It will not be superfluous to give a few additional figures in order to show variations depending in part upon the manner in which the measurements have been taken and in part upon natural variations in the length of the organ.

Klaus gives the length of the esophagus in a child of 2 months as 10 cm.; of 22 months, as 17.5 cm.; and at 3 years as 20.5 cm. These measurements are longer than those which von Hacker gives.

Viedordt gives the following table.

Age	Length of Esophagus	Distance from Incisor Teeth to Upper Border of Cricoid	Distance from Teeth to Cardia
	cm.	cm.	cm.
3 weeks to 11 months	13.5	6.2	19.7
1 year to 22 months	16.9	7.7	24.8
3½ years	20.5	9.5	30.0

Diameters.—For practical purposes, the following measurements from Jonnesco give with sufficient accuracy the diameters of the adult esophagus at the level of the various normal constrictions.

At the level of the cricoid cartilage, with easy distention, 23 mm. transversely x 17 mm. sagitally.

At the level of the arch of the aorta, 24 mm. transversely x 19 mm. sagitally.

At the level where the esophagus is crossed by the left bronchus, 23 mm. transversely x 17 mm. sagitally.

In its passage through the diaphragm, 25 mm. transversely x 24 mm. sagitally.

These numbers are of importance only in connection with the passage of instruments through the esophagus. Menhert believes that the most constricted portion of the human adult esophagus is only 11 mm.; von Hacker, that it is 13 mm. All agree that the most constricted portion is at the level of the cricoid cartilage.

I agree with Sesbini and Jonnesco, that these diameters are too small. Even in children of 5 years, the esophagus should measure 12 mm. at its most constricted portion. I have easily passed an esophagoscope measuring 11 mm. into the esophagus of a child 4 years old, and one of 7 mm. into that of an infant. Much confusion arises from the fact that the entrance to the esophagus—that portion posterior to the cricoid cartilage—is slit-like in character, the result of its compression between the larynx and the vertebral column.

Upon the least extension of the head the depression of the hyoid bone accentuates the slit-like character of the opening and opposes any approximation to the circular form.

Course.—The course of the esophagus from the cricoid cartilage to the opening into the stomach, in the adult, with the head in the erect position, is as follows: It begins in the median line at the level of the sixth cervical vertebra, lying lightly compressed between the upper border of the cricoid cartilage and the vertebral column. It then passes downward between the trachea in front of the vertebral column, into the posterior mediastinum; here it is crossed by the arch of the aorta in front of the fourth dorsal vertebra, and, inclining to the left of the vertebral column, it is crossed, opposite the fifth dorsal vertebra, by the left bronchus, which passes in front of it, downward and outward. To its right, in this situation, is the vena azygos major, which crosses the esophagus at the level of the interval between the fourth and fifth dorsal vertebræ. To its left is the arch of the aorta and in front is the pericardium. Below this level the esophagus again lies in the middle line, in front of the bodies of the dorsal vertebræ; but at the level of the seventh dorsal vertebra it again leaves the middle line, inclining toward the left. In front of the eighth dorsal vertebra, and below the costal cartilage of the fourth rib, the esophagus crosses the anterior surface of the aorta from right to left. It then inclines further to the left until it enters the esophageal opening of the diaphragm. Although it is to the left of the middle line, it is still separated from the bodies of the vertebræ by the aorta and vena azygos major. Its passage through the diaphragm is on a level with the tenth dorsal vertebra, 8 cm. behind the angle between the xiphoid and the costal cartilage of the seventh rib. Within the abdomen it passes slightly forward and to the left to its transition into the stomach.

OBJECTIVE EXAMINATION OF THE INTERIOR OF THE ESOPHAGUS

Preliminary History Taking.—Before proceeding with any objective method of examining the esophagus, it is desirable to know the patient's history. Certain facts in the history may be almost pathognomonic of specific conditions and will prove valuable guides in applying any of the objective means of examination.

Any direct cause for the patient's condition should be carefully inquired for. The possibility that the patient has swallowed a foreign body which may have become lodged within the esophagus is of much importance. Of equal significance is the knowledge that the patient has, within a few weeks' time, swallowed a caustic alkali or acid. It is not infrequent for patients who have attempted suicide to conceal the fact that they have previously swallowed some corrosive poison.

Of all the symptoms of esophageal disease, none exceeds dysphagia in importance. It is most desirable to know the time and character of the onset of dysphagia, whether it developed suddenly or gradually, whether it remits or intermits, or is progressive.

Next in importance to the dysphagia is regurgitation of food. The character of the regurgitated fluid should be ascertained in order to discover any digestive changes, or whether it is returned in approximately the same condition in which it was swallowed. The quantity of mucus in the vomitus must be estimated, and particularly it should be noted whether any blood is present. The frequency of the attacks of vomiting and whether they are synchronous with any change in the contour of the patient's neck are also significant facts.

Preliminary Physical Examination.—Before undertaking the objective examination of the esophagus, it is essential to make a physical examination. Failure to recognize an inflammatory process within the esophagus itself or within the mediastinum, pleura, or pericardium, or to ascertain tendencies to hemoptysis or hemophilia, may lead to serious consequences. The presence of a tuberculous focus within the lung, or any disturbance of normal respiration or of valvular lesions within the heart—particularly cardiac lesions which could result in embolism—the height of the blood-pressure, the condition of the arteries, and the presence or absence of aneurysm are equally important and should be ascertained before a direct examination of the esophagus is undertaken. While esophagoscopy may not be positively contra-indicated in any of these conditions, it is wiser in their presence not to undertake it unless it should be urgently indicated—as, for instance, for the sake of removing a foreign body.

Unquestionably, esophagoscopy is the most important of the methods of examining the esophagus—in fact, without it, an examination of the esophagus cannot be considered complete. Even the information to be derived from a good bismuth radiograph is second in importance to the esophagoscopic findings, as will be more fully referred to later on in this discussion. Though the esophagoscopic findings are both negatively and positively complete and absolute, certain other methods of examination cannot be passed over as useless.

These are: (1) examination by sounding; (2) Strauss' method; (3) Rumpel's method; (4) Mixter's method and Plummer's application of this method to diverticulæ; (5) X-rays.

Sounding.—For purposes of sounding the esophagus, either olives of various sizes screwed on the ends of a flexible metal or whalebone stem, the silk-woven esophageal bougies, or the ordinary stomach tube may be used. The stomach tube is really the best instrument for sounding purposes. *It is soft, incapable of injuring the esophagus, and will give all the information which it is necessary to ascertain by this method.*

With the patient in the sitting position and the surgeon standing and facing him, the end of the stomach tube is passed over the base of the tongue and into the esophagus. Its entrance into the esophagus is facilitated by requesting the patient to swallow. After the stomach tube has passed the entrance to the esophagus, its subsequent passage through the remainder of the esophagus is easily effected by merely pushing it further along and by requesting the patient to continue swallowing. In nervous patients or in patients with sensitive pharyngeal reflexes, a very great advantage is gained by swabbing the back of the tongue with a 10 per cent. solution of cocain.

The passage of a stomach tube in this manner will demonstrate the presence and exact location of a suspected stenosis. Its use forms a valuable preliminary procedure and is applicable to all esophageal lesions except acute inflammatory processes and foreign bodies.

Strauss' Method.—The diameter of the esophagus at any point in its course may be determined by the Strauss method, or, better, by the modification suggested by Plummer. Strauss fastens a rubber bag over the fenestrum of a stomach tube. This rubber bag is covered with a silk bag to prevent overdistention. The stomach tube is then passed into the esophagus, and the surgeon determines the degree of distention of the rubber bag necessary to just fill the esophagus, thus ascertaining the diameter at any desired place. Plummer simply replaces the single silk bag of Strauss with silk bags of various sizes. In this way there is less danger of overdistending the esophagus. The diameter at any level will correspond to that of the silk bag which, when distended, fails to move freely up and down within the esophagus.

Rumpel's Method.—Rumpel has devised a method to measure roughly both the capacity and diameter of the esophagus. He ties a large thin rubber bag over the fenestrated tube. This is then passed into the esophagus, and water is allowed to flow into the rubber bag until the esophagus is filled. The rubber tube is then passed into the stomach far enough to admit the lower fenestration, but not the upper. As soon as this has been accomplished, water flows from the portion of the rubber bag within the esophagus into that portion within the stomach. The method prevents a confusion of the cavity of a dilated esophagus with that of the stomach—a mistake which has frequently occurred during the examination of patients suffering from dilated esophagi. A disadvantage of the method is that it is difficult to pass the tube into the stomach in those patients in whom its use is most desirable.

Mixter's Method.—Another method of ascertaining the diameter of stenosed portions of the esophagus is by passing a series of different sized bougies upon a thread. This is a valuable method, and may also be used in the treatment of benign stenosis, and it is one of the most certain means of demonstrating the presence of a *diverticulum* of the esophagus. It also forms the safest method, exclusive of esophagoscopy, of entering the stomachs of patients with dilatation of the esophagus.

Frequently, in these patients, the lowest portion of esophagus is below the cardiac orifice, so that pocketing of the end of the sound, with disastrous results, may easily occur if the sound is not guided by means of the thread into the cardiac orifice. Dunham first suggested passing bougies upon a thread which had been swallowed and drawn taut through a gastrostomy opening. Mixter, however, found that the gastrostomy was unnecessary; that if a piece of thread *6 yards long* was swallowed, sufficient would pass into the small intestine to make it possible to hold the thread taut by its upper end and pass a bougie upon it. By this method olives of increasing size screwed upon a flexible stem may be passed safely through very tight strictures which may thus be dilated. The method is applicable to the diagnosis of diverticula in the following manner: The threaded olive first enters the diverticulum. The thread is then pulled taut, and by this means the olive is lifted out of the diverticulum into the esophagus. In consequence of the greater ease with which the olive enters the diverticulum, it first descends until it meets the obstruction formed by the bottom of the diverticulum. Its further progress can only be accomplished by lifting it out of the diverticulum so that the olive, in order to pass the full length of the esophagus, must first descend, then ascend, and finally descend again. Such a course is typical of the presence of an esophageal diverticulum. (See Fig. 1.)

Röntgen Rays.—The fifth method of examining the esophagus is by means of the Röntgen rays. (For the discussion of the application of the X-rays to esophageal lesions see Vol. IV, Chapter III.)

It is generally recognized that a good radiograph of an esophagus, the inner wall of which is coated with a suspension of bismuth, furnishes information of the first degree of importance. It is unquestionably the best method of demonstrating diverticula. In the case of a new growth it furnishes positive information regarding its presence and location. It determines the degree of dilatation of the esophagus, and is an absolute method of diagnosticating the presence of foreign bodies.

In regard to new growths and stenosis of the esophagus, however, radiographs have at times been misleading. The accompanying radiograph of a patient with a benign stenosis of the lower extremity of the esophagus illustrates how easily confusion may arise if entire dependence is placed upon a radiograph. From the radiograph which is reproduced in Figure 2, one of the most expert radiographers in New York gained the impression that a stenosis existed high up in the esophagus. As a matter of fact, the patient's only lesion was a benign stenosis of the lower extremity of the esophagus. The writer's experience justifies the view that it is not desirable to place entire reliance upon the X-ray examination, even though no examination of the esophagus at the present time can be complete without one.

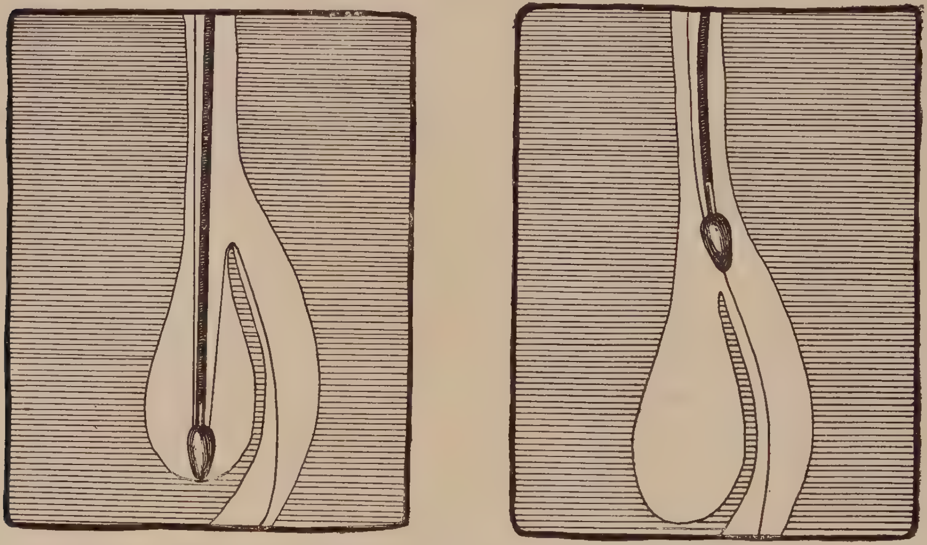


FIG. 1.—MANNER IN WHICH A THREADED OLIVE IS LIFTED OUT OF THE DIVERTICULAR SAC BY THE PREVIOUSLY SWALLOWED STRING.

Dr. A. C. Crump recently devised a very ingenious and valuable method of examining the esophagus in connection with the X-rays. He has been kind enough to describe the procedure as follows:

THE USE OF SAUSAGE SKIN IN THE DIAGNOSIS AND TREATMENT OF ESOPHAGEAL STRICTURE

"PREPARATION.—Sausage skins are obtained from the slaughter house in the cleaned and prepared state, as used for packing sausage, under the trade name of 'casings.' They can be obtained in various sizes and degrees of toughness. The skins are placed in jars and thoroughly salted with dry table salt, to preserve them. To prepare them for use, lengths of about 60 mm. are cut from the prepared skins and placed in lukewarm water, to soften. They are then washed thoroughly, inside and out, in running water. Next, the skins are placed in a solution of ½ per cent. formalin and ten per cent. glycerin, to harden, for fifteen minutes, then rewashed. If they remain in the solution too long, they will lose their tone.

"One end is next closed with a pair of artery clamps, and the opposite end is run over a funnel. Water is allowed to run in from the tap to test out the skin for evenness and to see if there are any holes. A better membrane is made by invaginating the skin and stretching it on a form, so as to preserve an even caliber throughout. Any adherent mucosa should be scraped off while the skin is wet. The skin is then allowed to dry, and removed from the form. It will keep indefinitely.

"When it is desired to use the skin, it is placed in lukewarm water, to soften. One end is then tied with silk floss, the floss being wrapped around several times. A long bag is thus formed, and connection is established with the irrigator by tying the open end to a small tube.

"In the collapsed state, the bag is only a string. Before giving this to the patient, it is best to cocainize the pharynx and esophagus in order to prevent retching and coughing. The patient's stomach should also be empty. Cocainizing, however, is not always necessary, except in the treatment. The patient swallows the skin with the aid of a little water. If the stricture is not a difficult one to pass with a small bougie, time may be saved by running the skin over a No. 10 French round-ended silk bougie, then passing both together, withdrawing the bougie when the skin is in place. It is surprising how easily a patient with the smallest stricture can swallow one of these skins, and how readily it will untwist itself on being filled.

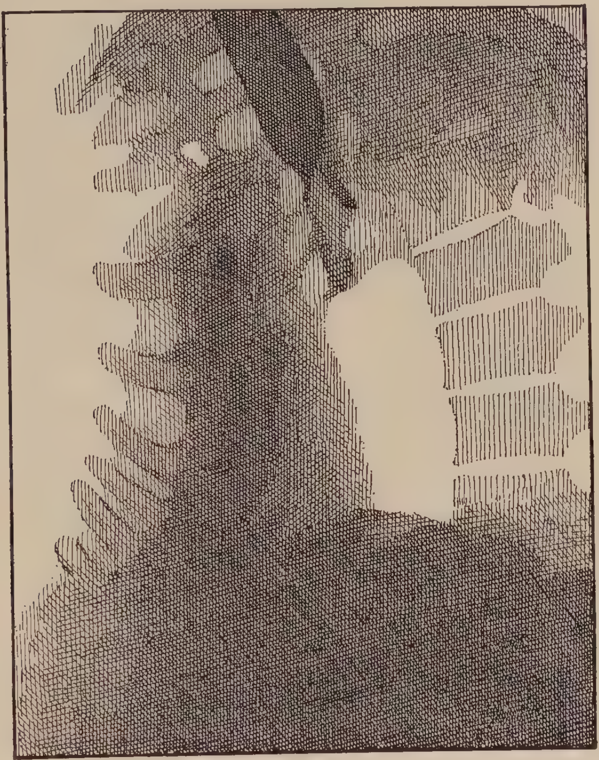


Fig. 2.—Radiograph from a Patient with Cicatricial Stenosis at the Cardiac Constriction of the Esophagus. The radiograph led to the diagnosis of cancer of the middle of the esophagus.

"For X-ray Work.—After the skin has passed the stenosis, a thick bismuth mixture is allowed to flow in from an irrigator holding 200 c. c. After the bismuth mixture has reached the lower end of the sack, the skin should be withdrawn slightly for the purpose of untwisting any kinks that may have formed. The filling and pulling should be continued until the skin is filled to the level of the pharynx. The irrigator is then removed and the rubber tube is clamped. The patient is then given a couple of tablespoonfuls of bismuth to swallow outside of the skin—a teaspoonful at a time. This is to fill any irregularities or pockets that the bag does not outline. The patient is then ready for screen or plate examination. (See Fig. 3.) This method will give the extent of esophageal involvement, distal as well as proximal, to the stricture.

"There may be some difficulty in removing the bag in the smaller strictures, but this need not occasion alarm. The patient is placed face downward over the edge of the table, and gentle but firm traction is made on the skin, pulling by the tube and holding it over some vessel. It is of the greatest importance to proceed slowly and carefully. Naturally, with a small stricture, it will take a few minutes for the thick bismuth to pass the opening. It is wise to inform the patient beforehand in regard to this.

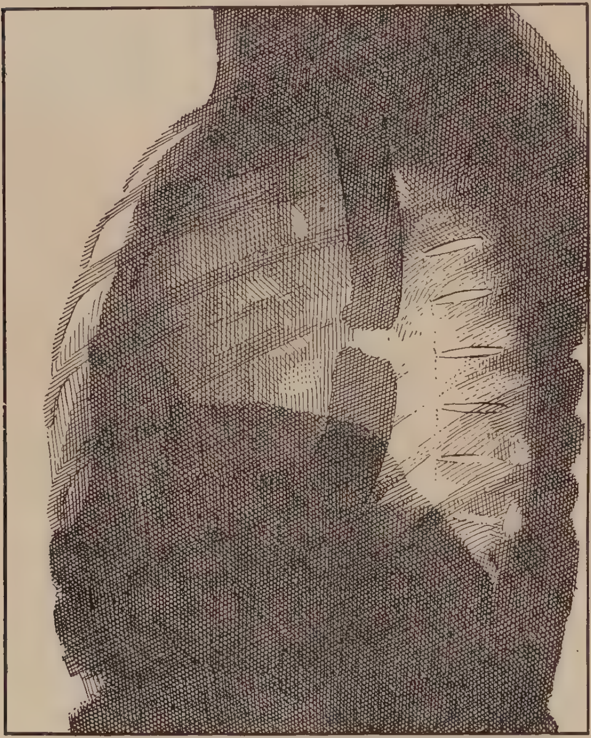


Fig. 3.—Radiograph after the Insertion of Dr. Crump's Bismuth-Filled Membrane.

"Treatment.—For this purpose, the thicker and tougher skins should be used. The connecting tube at the mouth end should be large enough to admit whatever instrument is to be used. About 60 c. c. of a bismuth-glycerin mixture, diluted with water to the consistency of molasses, is poured in through this tube. The weight of the mixture will draw the walls of the skin taut. This manipulation will enable the bag to direct any instrument to the center of the stenosed area more accurately than a silk thread. It is hardly possible to run the tip of the instrument into pockets. The time of passage of the bougie is a matter of only a few minutes. Tragacanth and Irish moss, when made up to the consistency of thick molasses and flavored, is the best lubricant. For retrograde dilatation, remove the connecting tube from the skin, after running in the 60 c. c. of thick glycerin-bismuth mixture, and tie up the end with silk tape, the ends of which are left long. A urethral silk catheter of 18 to 20 French, with tip cut off and smoothed, is then passed over the tape and skin to the site of the stricture. The tape is then pulled tight while the catheter is held in place, so as to balloon the lower end of the skin. Steady traction is then given the catheter and tape, care being taken at the same time not to exert too much force. The skin, however, will act as a safety valve, and will break if too much force is applied. The pressure can be varied by manipulating the tape and catheter.

"The skins may also be used with the esophagoscope and mechanical dilators, the slippery nature of the skins allowing the instruments to be more easily passed within them, thus limiting the amount of trauma to the esophageal mucosa. Inasmuch as the skins are obtainable in any community, they render possible the performance of various procedures, including retrograde dilatation, which would otherwise require an elaborate set of instruments and a technic which is not possessed by the general practitioner."

ESOPHAGOSCOPY

The above methods of examination have been mentioned for the sake of completeness. It is the chief purpose of the present chapter to consider the direct visual examination of the esophagus and stomach.

A brief review, however, of the history of esophagoscopy and gastroscopy should properly precede the consideration of the present-day methods and their results because such a reference will best demonstrate the development of the present types of instruments and the reasons why certain ideas concerning the construction of instruments for examining the esophagus and stomach, which are continually being revived, should be forever discarded.

History.—All endoscopy dates back to Phillip Bozzini, who can properly be called the father of endoscopy, irrespective of the region in the body to which it is applied. In 1867, he published his work: "Der Lichtleiter oder Beschreibung einer einfachen Vorrichtung und ihrer Anwendung zur erleuchtung inneren Höhlen und Zwischenräume des lebenden animalschen Körper." It was the promulgation of a new idea in medicine, and opened up a new field for diagnosis of disease. In many respects it has amply fulfilled the expectation which Bozzini entertained at that time for his discovery. Like many new discoveries, it was not favorably received during Bozzini's life and he himself did little with it. It was at least 50 years later before any new attempts were made to utilize Bozzini's idea. The attempts which were then made were undertaken by men devoting themselves exclusively to various branches of medicine, affections of the bladder, rectum, etc., each endeavoring to perfect endoscopy for his own field of work.

Manuel Garcia, in 1856, made the first attempt to apply endoscopy to the esophagus. He barely saw the entrance to the esophagus. He was followed in 1860 by Voltolini and Semeleder, neither of whom was more successful. The latter recognized the slit-like character of the entrance to the esophagus, and attempted to spread it by inserting forceps which separated laterally, thus transforming the orifice of the esophagus into an opening resembling the figure 8.

Bevan, of England, in 1868, really constructed the first esophagoscope. It consisted of a straight tube, 4 in. long, fitted with a mirror at the upper end, by means of which the light was reflected through the tube. When in position, the tube was supported with a handle, the 2 fork-like divisions of which supported the instrument on either side of its upper end. He soon modified his instrument to consist of 4 rods jointed together at equidistant points around the instrument, so that the mucous membrane of all that portion of the esophagus into which the instrument was inserted could be examined at once. Two years later, Woldenburg, apparently without the knowledge of Bevan's instrument, constructed a very similar one. Woldenburg's esophagoscope was 14 cm. long and 7 mm. in diameter. He also constructed a longer tube capable of being passed through the first one. The illumination, as in Bevan's instrument, was obtained by means of a laryngoscopic mirror placed at the top of the instrument. With his instrument, Woldenburg diagnosed a pressure diverticulum.

Stoerk attempted to use the Woldenburg instrument, but soon concluded that it was too uncomfortable a procédure for both patient and surgeon. In order to overcome this difficulty, which chiefly concerned the introduction of the instrument, he attempted to develop the idea of a flexible tube which could be introduced in a curved condition. The idea was not original with him, but was suggested by a tracheoscope published in 1869 by Durham. Stoerk constructed an 11 cm. tube which was manipulated by a forked handle, like the Woldenburg esophagoscope. It could be introduced in a flexible condition and then transformed into a rigid tube by rotating it through an arc of 90°. The illumination was obtained by a laryngoscopic mirror. The instrument was covered by a rubber tube for the sake of protecting the mucous membrane. It had the modest external diameter of 20 mm., with a lumen of 13 mm. At the time that Stoerk published a description of this instrument, he considered that it met the requirements in an ideal manner. Nevertheless, he later constructed another instrument of greater length, in which he relinquished the principle of a flexible instrument for one which was composed of 3 parts and which could be telescopically lengthened out from 8 to 20 cm. Finally, in order to see the cardia, he gave up this last idea and adopted the simple straight tube, which he introduced with the aid of an obturator. Considering, however, that the introduction of this instrument caused too great discomfort, he constructed a final instrument of sufficient length to reach the cardia, but with a flexible distal portion which could be converted into a rigid tube by rotating it about 180°. Stoerk extracted many foreign bodies from the esophagus and diagnosed a number of benign and malignant strictures of the esophagus. He used his instrument throughout his whole life, and gave many demonstrations. Nevertheless, he was unable to make the procedure popular, a fact which he deeply regretted. He, however, rendered a definite service, for which his name deserves one of the first places in the history of esophagoscopy. He was really the first man to make systematic use of this method of examination.

About the same period, Kussmaul practiced esophagoscopy. He imported through his assistant (Housell) the Desormeaux lamp from Paris. While practicing upon a sword swallower whom he met by chance in Freiburg, he learned the use of long straight tubes. He was the first to diagnose cancer of the cardia. He used 47 cm. tubes, one oval and another round. The diameter of the latter was 13 mm. From the examination of many patients, Kussmaul concluded that a tube 13 mm. in diameter could be passed upon all normal individuals.

In 1881 came the epoch-making work of von Mikulicz, "Ueber Gastrostomie und Oesophagoscopie." This work represented 1 year's experimenting upon the cadaver and a considerable clinical experience. It at last placed esophagoscopy upon a firm basis and introduced the modern technic and conclusions concerning this method of examination. Von Mikulicz demonstrated that a rigid tube could be passed to the stomach on every individual who was not deformed. He concluded that only straight tubes and direct illumination should be depended upon for the future, and demonstrated the futility of using flexible tubes. Subsequent experience has abundantly supported these conclusions.

Von Mikulicz's esophagoscope consisted of a single straight rigid tube, 12 to 13 mm. in diameter. It was introduced with an obturator, after the removal of which the observation tube was inserted. The latter carried a small tube inclosing a platinum wire, the end of which formed a loop which was covered by a window and which furnished the illumination. Around the wire was space for a stream of water which kept the surrounding parts of the instrument cool.

In his first publication he described accurately the appearance of the normal esophagus. His descriptions of the clear-cut appearances of pathological conditions within the esophagus—2 cases of carcinoma, 1 case of compression of the esophagus, 2 cases of cicatricial stenosis, and 2 cases of foreign bodies, 1 of a tear of the mucosa, and 2 of ulcer—at once revealed the possibilities of esophagoscopy, and raised this method of examination from a position of doubtful usefulness to one of unquestioned value.

In 1882, von Mikulicz reported to the Surgical Congress the findings in 50 to 60 cases of esophageal lesions. Among these were 6 or 7 cases of diffuse dilatation of the esophagus. (At that time the literature contained only 20 reported cases.) He used morphin narcosis and placed the patient in the lateral position.

After his removal to Krakau, von Mikulicz's time became so occupied that he reported little further on esophagoscopy, and it was not until Gottstein published his "Technik und Klinik der Œsophagoscopie," in 1901, that any further information of the subsequent history of esophagoscopy was available from the von Mikulicz Clinic.

In 1887, von Hacker of the Billroth Clinic became deeply interested in esophagoscopy, and 2 years after his first experiments he was able to review the results of a considerable number of cases. In 1898 he reported the removal of 27 foreign bodies and declared that an internal esophagotomy had not been necessary at the Billroth Clinic since he had learned the use of the esophagoscope. He used the rigid straight tube and an obturator for introduction, but introduced proximal illumination by the panelectroscope, manufactured for him by Leiter. With the means at that time available for distal illumination, this was a great improvement. Von Hacker also added the important innovation of cocainizing the pharynx instead of employing morphin and chloroform narcosis.

Rosenheim—almost contemporaneously with von Hacker—worked out a very similar instrumentarium and technic for esophagoscopy. He introduced the use of the solid rubber obturator and the Casper panelectroscope. He published a considerable number of clinical experiences which served to establish more firmly the reputation of esophagoscopy.

Kirstein introduced at this time the head light which bears his name and which further simplified esophagoscopy. He also contributed to the clinical knowledge of esophagoscopy by several publications.

In 1897, Kelling of Dresden attempted to use a flexible tube which could be transformed into a rigid tube after introduction. Though he made important clinical contributions, his instrument was not a success. In some cases its introduction was even more difficult than that of the straight tube.

Einhorn was the first to use a distal cold lamp, and Schreiber added an auxiliary suction tube for cleansing purposes.

In 1903-4, Gluckmann described a very complicated esophagoscope in which provision was made for water dilatation of the lower end of the esophagus and for its examination by a system of lenses, the surface of the objective being kept clean by irrigation. This attempt is mentioned only for the sake of completeness.

It is hardly necessary to state that, aside from the numerous inconveniences and frequent disappointments which are always associated with complicated instruments, their use is rendered superfluous because all the requirements are so amply met by the straight esophagoscopes. Practically all work of any importance in the development of esophagoscopy has been accomplished with the straight tube. It is, however, desirable to bear in mind the experience of these earlier experimenters, since every now and then one sees cropping out in the literature descriptions of new instruments which represent some variations of these older discarded principles. This statement particularly applies to the attempts to get away from the straight tube by the use of some flexible or angulated instrument. Flexible and angulated instruments have been tried out and found not so satisfactory or successful as the straight esophagoscopes.

There is a consensus of opinion regarding the superiority of the straight instruments among those who have done the best clinical work with the esophagoscope. Von Hacker, Rosenheim, Kirstein, Killian, Gottstein, Kraus, Starck, Sencert, Guiscz, Jackson, Plummer, Lerche, Hill, and many others who could be mentioned, believe that the original conclusion of von Mikulicz is indisputable, i. e. that the single straight esophagoscope, for both the surgeon and the patient, best fulfills the indications of esophagoscopy. This is the instrument which today is used universally. Many workers have made their own individual variations, but in general the type of instrument designed by von Mikulicz is the one which is used to-day by all who are doing active esophagoscopic work.

Types of Instruments.—Considerable difference of opinion still exists regarding the relative advantages of proximal or distal illumination. Chevalier Jackson has been responsible for demonstrating the superior value of distal illumination. Although I believe that distal illumination is superior, this belief is not universally shared.

Proximal illumination is still very widely used in this country as well as abroad. I believe with Dr. Jackson that it will be used less and less. The improvements in the manufacture of small electrical lamps have made possible an entirely practical and very efficient form of distal illumination. The heated platinum filament with the current of water for cooling purposes is no longer necessary. Bulbs of bead-like size are now manufactured which possess brilliant illuminating power and yet do not become hot. The conducting wires can be inclosed in such a manner that they will occupy little space. The improvements in the manufacture of these lamps have opened up a new chapter in esophagoscopy.

The only disadvantage of distal illumination, namely, the diminution in the size of the lumen of the esophagoscope, has been so far diminished that it need no longer be considered. On the other hand, distal illumination gives the very great advantage of bringing the light close to the area to be examined. Its rays are not obscured during instrumentation in the manner that parallel rays from the proximal end of the tube are dimmed. In proximal illumination, the rays must be projected from a head light, as the Kirstein light, or from an electroscope. When projected from a head light, much inconvenience is caused by the necessity for keeping the parallel rays in exact line with the direction of the tube. In fact, Starck advised that the esophagoscope and head light should be united in order to prevent deviation of the rays of light when the rays are projected from an electroscope. The electroscope itself interferes in some degree with the instrumentation through the esophagoscope.

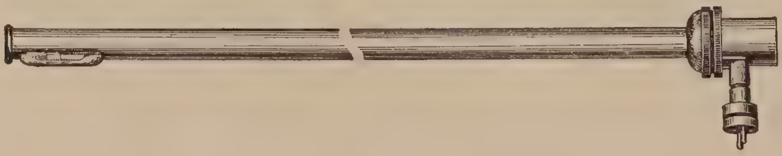


FIG. 4.—THE AUTHOR'S ESOPHAGOSCOPE.

To those preferring proximal illumination, the writer recommends the electroscope of Dr. Nathan Green, which is one of the most serviceable yet devised.

The accompanying illustration pictures the instruments of some of the various authors named. That of Dr. Jackson is most extensively used in this country.

Figure 4 represents my esophagoscope. It differs from the Jackson instrument in the elimination of the lateral tubes for purposes of carrying the lamp and permitting aspiration. At the distal end of the instrument is a small recess in the outer wall of the tube into which the lamp falls when introduced into the sheath. The lamp is attached to a separate tube of extreme thinness by means of a tongue-like spring. When this inside tube is introduced within the outer sheath, the tongue springs the lamp into the recess. It is thus not only hidden entirely from the eye of the observer, but does not obstruct the lumen of the tube. The sheath of the tube to which the lamp is attached is so thin that it reduces the lumen of the external sheath by less than $\frac{1}{2}$ mm., an amount insufficient to make any material difference to the observer.

The provision made for accommodating the lamp in a small recess at the distal end of the instrument enables one to use a perfectly round sheath for practically the full length of the esophagoscope, a feature which I consider an advantage. It may be argued that the location in which it is especially desirable to maintain a small diameter in an esophagoscope is at the portion passing through the cervical esophagus and that here only the anteroposterior diameter is important; yet when a full set of teeth is present it is less difficult to pass the instrument at the side of the mouth and in this situation it is the opposite diameter—the transverse—in which it is desirable to economize space. On this account, a round instrument is the most serviceable. The obturator is not inserted within the instrument at the beginning of the introduction. After the opening of the esophagus is located by the eye, it is occasionally useful to overcome the resistance to the entrance of the esophagus by passing the obturator through the entrance of the esophagus and then to withdraw the obturator. This procedure sometimes facilitates passing the instrument through the mouth of the esophagus and does not interfere with the examination of the entire length of the canal.

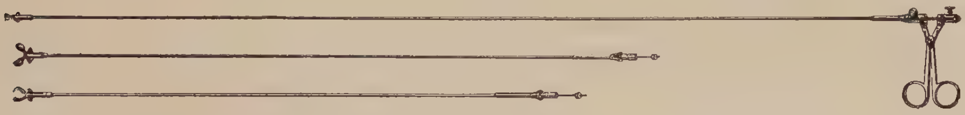


Fig. 5.—Intra-esophageal Forceps for the Removal of Foreign Bodies and Bits of Tissues for Microscopical Examination.

The addition to an esophagoscope of an auxiliary tube for aspirating purposes is superfluous, and, therefore, is objectionable because of the extra space which it occupies. It is much better to aspirate the fluid contents of the esophagus by a separate tube passed within the instrument each time that aspiration becomes necessary. Such a tube can be connected by a small rubber pipe to a bottle in series with a water suction pump screwed to a faucet. The pressure in the bottle may be regulated to any degree desired by the rate at which the water is allowed to run. Within the esophagus of an individual properly prepared for examination repeated aspirations are unnecessary. After withdrawing the secretions, once or twice, the lumen remains empty. It is better to withdraw the secretions through a large tube than through the small collateral tubes incorporated in the instruments of the other type, as thus the secretions can be withdrawn quickly and the more solid or viscid portions will not clog the aspirating tube. When the stomach of a patient who has fasted for 24 hours—or at least overnight—is cleansed thus, it will remain free from fluid.

Figure 5 represents the forceps which may be used for the removal of foreign bodies or bits of tissue for microscopical examination. The ends occupy very little space and yet possess a wide angle of rotation, so that it is easy for them to secure a very firm bite upon any object which it is desired to catch between them.

The outside diameter of the sheath of my esophagoscope measures 11 mm. and the instrument is 18 inches (45 cm.) long. Another size is 9 mm. in diameter and 12 inches (30 cm.) long. A third is 7 mm. in diameter and 15¼ inches (38 cm.) long. These 3 sizes are needed for the various examinations which may be required. The outer surface of the esophagoscope should be as smooth as possible and should be marked with fine lines at centimeter intervals, each mark indicating the distance from the aboral end of the tube. The inner surface of an esophagoscope should not be polished but roughened in a manner which will scatter the rays of light and prevent them from being reflected into the eye. It does not seem possible to attain a permanent blackening of the inside surface of the instrument.

In the description of the various types of instruments which have been used for esophagoscopy, mention has not yet been made of an instrument which has been perfected recently by Dr. Lewisohn. In this instrument several old ideas are combined so ingeniously that it would be most ungenerous to take issue with Dr. Lewisohn's claim that he has originated a new principle in esophagoscopy.

It is right-angled and may telescopically be lengthened out after its introduction into the pharynx. The object of the instrument is to enable the operator to view the whole of the esophagus without extending the patient's head. The mechanism is obviously complicated. The esophagus is viewed indirectly through a prism, and all instrumentation must be done around a corner. The instrument is thus adapted chiefly for diagnostic purposes. Dr. Lewisohn contemplates perfecting his instrument so that foreign bodies and bits of tissue for microscopical examination can be removed through it. If he succeeds in so doing, and if, after further use of his instrument, he is able to introduce it with less discomfort and to examine and perform the various manipulations within the esophagus with the same speed and facility with which they can be accomplished through the straight tube, he will have made an advance in esophagoscopy. However, the experience of von Mikulicz, namely, that the straight tube can be introduced with little discomfort in the normal individual and that the various manipulations through it are simple, is universally confirmed by all who have acquired skill in esophagoscopy and gastroscopy. Very strong reasons must exist, therefore, before it will be replaced by even such a type of instrument as Dr. Lewisohn has devised.

THE TECHNIC OF ESOPHAGOSCOPIC EXAMINATION

Preparation of the Patient.—It is assumed that a detailed history has been taken, that a physical examination has been made, and that all contra-indications to the procedure have been excluded.

The mouth of the patient should be examined and cleaned. If there is time before the operation, any hopelessly decayed teeth should be removed, and other diseased teeth should be properly filled. It is absolutely essential that the stomach and esophagus shall be empty. No food should be taken for at least 12 hours before the time of the examination. In special cases food must be withheld for a longer period.

Anesthesia.—It is not necessary to give general anesthesia for an esophagoscopic examination in the average patient. As has been said, one accustomed to making these examinations can pass the tube in the normal individual with only trivial discomfort to the patient. The administration of a general anesthetic may be needed in certain deformed individuals and in nervous patients. I believe that when general anesthesia is indicated, intratracheal insufflation is the method of choice. For practically all cases reliance should be placed entirely upon morphin and a local application of cocain. Morphin should be given in a liberal dose, as much as ⅓ gr. combined with atropin to many patients. It should be injected hypodermically 1 hour before the esophagoscopic examination. Immediately preceding the examination, the posterior surface of the tongue, tonsils, and pharynx should be touched with a 10 per cent. solution of cocain. A second swab of cotton, securely fastened upon the end of the applicator, should be pushed down into the esophagus at least as far as the cricoid cartilage; and a third swab, if possible, through the cervical constriction at the entrance of the esophagus.

Position of the Patient.—The patient should then be placed in the position in which it is chosen to make the examination. Esophagoscopists differ as to the best position. A few select the sitting position. In the experience of the majority, including myself, the sitting position is not nearly so convenient, safe, or comfortable for the patient. A number of examiners—von Mikulicz, Gottstein, Rosenheim, Kelling, Reizenstein, Harmer, Jackson—use the lateral position. Von Hacker has been in the habit of introducing the tube in the sitting position and then placing the patient either on the back or the side. He particularly states that patients who have occupied both the lateral and the dorsal position prefer the latter. The majority of workers prefer the dorsal position. Starck has used both positions, according to what he believes to be special indications for the one or the other. I also have used both positions, but prefer the dorsal position. In the lateral position the patient constantly presses his shoulders backward. In the dorsal position all patients are much more comfortable, it is far easier for them to remain quiet throughout the examination, and there is no tendency toward displacement of the shoulders.

A number of workers have advised so adjusting the table that the head is lower than the feet, in order to prevent fluid from gravitating to the lower portion of the esophagus during the examination. I am convinced that better results are obtained if the table is so inclined that the contents of the esophagus will gravitate toward the stomach. After the fluid once has been aspirated, sufficient will not collect during the remainder of the examination to annoy the examiner. The patient's comfort is greatly contributed to by preventing the fluid from flowing out of the mouth and through the nose, as it invariably does when the oral end of the esophagus is lower than the aboral end. Moreover, in the dependent position of the upper extremity of the esophagus the congestion in the head is greater and far more disagreeable than when the head is higher. When the head of the table is raised to permit of the proper inclination of the esophagus, it is important to provide against the patient slipping toward the foot of the table. The knees of the patient should be flexed, in order to relax the abdomen. Many devices have been contrived to hold the head. It would be useful if some rest could be made to hold the head and at the same time permit a change of position. A head-rest is more conducive to relaxation than the support afforded by the hands of an assistant, but no head rest has yet been devised that permits of the rapid and intelligent changes in the position of the head which can be accomplished by the hands of an assistant.

The Assistant.—The assistant who holds the patient's head is a most important factor in the examination. He should be trained to respond to the signals of the operator. The position known as the Boyce position, described by Dr. Boyce, is the most useful position for the assistant. It is substantially the one used by me. The assistant should take his position at the right of the patient, facing him. The assistant's right arm should pass behind the patient's neck and rest, if possible, upon a support attached to the table to the left of the patient. This arm will then form a support for the patient of a far more stable character than when the head rests in the free hands of an assistant. The patient appreciates the stable character of this method of support and will trust himself to the assistant with more confidence and greater relaxation. The left hand of the assistant should be placed upon the patient's forehead. In this position the correct amount of extension and rotation of the head can be secured.

The operator takes his place to the left, facing the patient. His instruments should be placed upon a table within easy reach, and to his right. A second assistant is required to hold the suction tube, to hand it to the operator, and take it from him when necessary. The relative positions of the surgeon, assistants and patient, with the various degrees of insertion of the gastroscope, are illustrated in Figure 6.

Introduction of the Esophagoscope.—The operator is now ready to pass the esophagoscope. Holding the instrument by its oral extremity with the right hand, and inserting the thumb and index finger of the left hand into the patient's mouth and with them spreading his lips, the aboral end of the esophagoscope is passed over the tongue and follows the pharyngeal wall downward until the epiglottis is recognized. In individuals with a full set of teeth, the shaft of the instrument should occupy the space between the lateral teeth of the upper and lower jaws. If a number of teeth are absent, it is advantageous to pass the instrument through such defects. When all the teeth are absent, the passage of an esophagoscope is facilitated, and any portion of the mouth may be occupied by the shaft. In normal individuals with a full set of teeth, an esophagoscope may be passed between the incisors, but more space is gained by passing

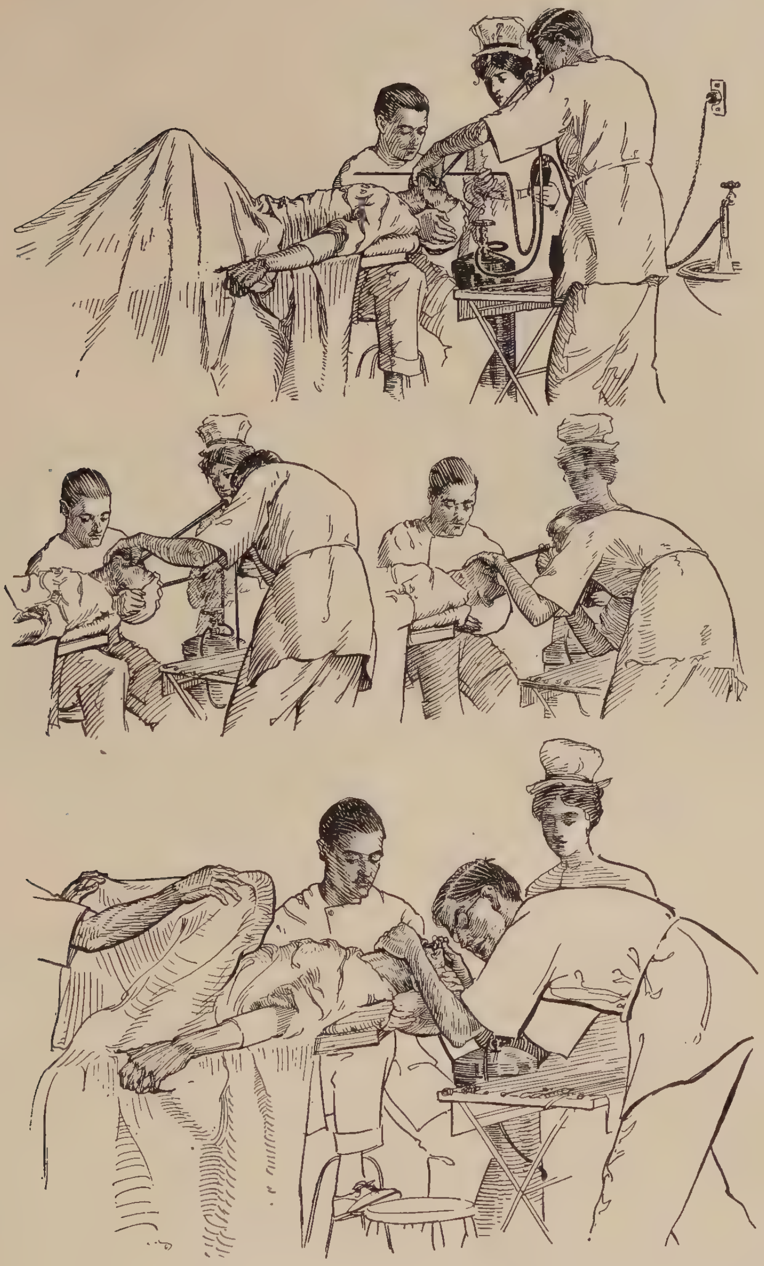


Fig. 6.—Relative Positions of Patient, Assistants, and Surgeon During the Insertion of the Esophagoscope or Gastroscope.

it to the side of the incisor teeth between the molars and bicuspids of the upper and lower jaws. The advantage of passing an instrument at the side is so great that it constitutes one reason for using an instrument which is round on cross-section.

During the introduction of the esophagoscope every centimeter of the distance traversed by the aboral end should be viewed by the surgeon. When the epiglottis is recognized, the instrument should be passed behind and to the right. The arytenoid cartilages come into view as the epiglottis is passed. Behind the arytenoids, which are passed to the side, the entrance to the esophagus will be recognized. With the head extended, the entrance to the esophagus is much compressed by the anterior group of sternolaryngeal muscles and has been described as slit-like. Nevertheless, through the esophagoscope it always appears circular and contracted about a central point or dimple which represents the lumen of the canal (Fig. 9). Varying numbers of furrows pass from the periphery to the central dimple.

The ease with which the esophagoscope can be forced onward depends much upon the direction which is given to the long axis of the instrument. Beginners are very apt to believe that the obstruction to the passage of the instrument at this level is due to insufficient extension of the head. This impression is produced by the projection forward of the anterior curve of the bodies of the cervical vertebræ in front of the lumen of the esophagoscope. Further extension of the head increases the difficulty. The long axis of the esophagus passes from above downward, posterior to the long axis of the body, deviating from the latter at an acute angle. The instrument should be held in the direction of the esophagus before it is passed onward. At the same time the aboral end of the esophagoscope should be lifted forward by the finger so as to lift the larynx and thus overcome the pressure exerted in a backward direction by the anterior hyoid muscles. With patients in whom a greater degree of resistance is encountered at the entrance to the esophagus an obturator of soft rubber is pushed only through the cervical constriction and immediately withdrawn. The arytenoids are passed on the side through the pyriform sinuses.

After this procedure, the esophagoscope enters readily. It is on account of the difficulty of entering the esophagus that von Mikulicz and Starck have insisted upon passing an esophagoscope with the obturator in situ until after the cervical constriction has been passed. This method of passing an esophagoscope is a blind one; as Chevalier Jackson and others have shown, the obturator is unnecessary and its use deprives one of the advantage of examining the cervical esophagus progressively from above downward. It is sometimes useful, however, after identifying the cervical constriction of the esophagus to pass an obturator just within this orifice.

After passing the cervical constriction, the discomfort experienced by the patient is slight and further progress is easy in the normal esophagus. Its walls fall apart as the end of the instrument progresses, since the normal intrathoracic esophagus is not a closed tube (Fig. 7). As the level of the aorta and left bronchus is reached, a definite convex prominence produced by these structures projects from the anterior wall. The oral end of the esophagoscope must be elevated and the head of the patient flexed, so that the aboral end of the esophagoscope can pass around the arch of the aorta and the left bronchus.

After these structures are passed, the head of the patient is extended to its former position and the further progress of the instrument is unobstructed until the cardia is reached.

Below the level of the bronchus the lumen of the esophagus is capacious; its walls come together and separate regularly with respiration. The subbronchial portion of the esophagus curves gently forward, this curvature increasing greatly at the cardia. The passage of the esophagus into the stomach is marked by a considerable curvature forward and to the left. At the cardia the second constriction is met. Furrows radiating from the periphery meet at a central dimple in the form of a rosette (Fig. 8). The resistance encountered at the cardia is more easily overcome than that at the entrance to the esophagus. Upon slight pressure forward, the central dimple dilates into a hole, which in turn enlarges and contracts with the respiratory movements. The constricted portion of the esophagus at the cardia is surrounded by the diaphragm, and measures from 2 to 3 cm. in length. The close relation of the diaphragmatic portion of the esophagus to the aorta causes the latter to impart a pulsation to the esophagoscope. As the esophagoscope passes through the cardia it emerges into the stomach. This transition from the esophagus to the stomach is recognized by the change in color of the mucous membrane. The color of the mucous membrane of the normal esophagus is pale red, while that of the stomach is of a deeper red and is thrown into folds (the rugæ of the stomach).

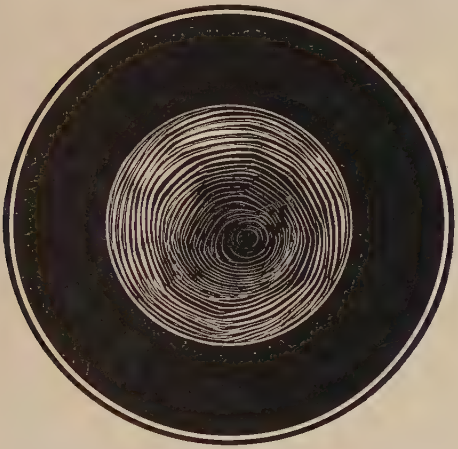


Fig. 7.—Normal Esophagus at Level of Lower Third.

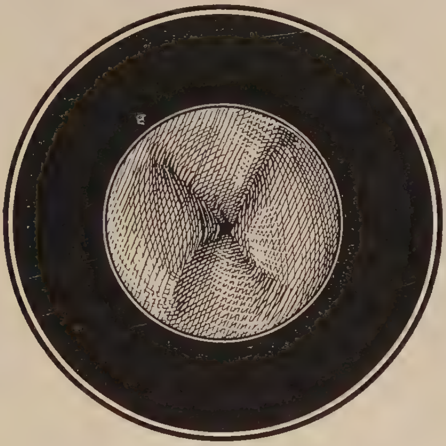


Fig. 8.—Normal Cardiac Constriction of the Esophagus.

THE DIAGNOSIS AND TREATMENT OF ESOPHAGEAL LESIONS THROUGH THE ESOPHAGOSCOPE

BENIGN CICATRICIAL STENOSIS

Etiology.—The simplest esophageal lesion is a benign stenosis. It is rather rare and is most often caused by caustic alkalies or strong acids which have been swallowed by mistake. Because of this fact, the lesion occurs more frequently among children. Cicatricial stenosis of the esophagus may result after a burn or a wound produced by a foreign body. It may occur after typhoid or diphtheritic ulcerations, or may follow tertiary syphilis of the esophagus. Guisez has observed only one case of syphilis of the esophagus. Downie, on the other hand, believes it to be fairly common and frequently overlooked.

Of 110 cases of benign stenosis collected by Lerche, and reported between the years 1890 and 1910, one half of the strictures occurred in children under 10 years of age. The majority were caused by caustics, and of these 82 were caused by caustic alkalies; 7 were caused by strong hydrochloric acid; 5 were caused by sulphuric acid; 3 by nitric acid; 2 by mixed acids; 2 by chlorid of zinc; and 2 by ammonia. He further states that of 100 cases collected by von Hacker previous to 1889, approximately the same proportions of causative agents were found. In this list no mention is made of foreign bodies. A number of isolated instances have occurred in which benign stenosis of the esophagus has developed from ulceration caused by long-retained foreign bodies.

The first changes which result from drinking a caustic are those of acute inflammation. These subside, and no further ill effects may be felt for a period of 2 to 8 weeks. At the expiration of this time a slowly increasing dysphagia may set in. If untreated, it will increase until it becomes absolute. Death may then follow from inanition. A number have terminated by perforation or from intercurrent disease dependent partly on the dysphagia.

Appearance Through the Esophagoscope.—The appearance of a benign stenosis, as viewed through the esophagoscope, varies much with the age of the process and the amount of infiltration of the walls of the esophagus. In some cases the esophagus will lead to the stenosis in a funnel-like form; in others, the lumen of the esophagus will not be diminished until the level of the stenosis is reached. Varying amounts of scar tissue may be present and aid materially in the diagnosis. In some cases these are present as bands stretching across the lumen; in others, as wide streaks; in still others, intermingled with redder, darker areas, producing a mottled appearance. Over the stenosed area, and frequently in the esophageal walls above it, the mucous membrane is pale and atrophic. The lumen of the stenosis may be eccentric, particularly in the aboral extremity of the esophagus; or it may be centrally placed, according to the degree of stenosis. The lumen may be partially opened, or it may be too constricted to admit a fine bougie through it. If the stenosis is recent, there may be exudative infiltrations of the walls and failure of the normal movements of the esophagus. Some limitation of movement is generally present in older strictures, but never that absolute immobility met with in carcinoma.

There is also an entire lack of the polypoid tumor formation usually found in cancer, unless fresh ulceration is present, when small granulomas, which may bleed easily, may be present. It is usually quite easy to differentiate them from cancer. Folds and furrows may exist in the walls of the stenosis, which will render the passage of the sound through the same difficult. Usually the walls of the stenosis are perfectly smooth and pale, or they may even glisten in the light from the lamp of the esophagoscope (Fig. 9).

Mortality without Esophagoscopy.—How death may occur in another manner, and the lessons to be learned therefrom, are best illustrated by von Hacker's series of 100 cases, reported before the days of esophagoscopy. Of these 100 cases, 25 died as a result of attempted dilatation by bougies. In nearly all the esophagus was perforated. In 2 cases the esophagus was perforated by a foreign body, causing the stenosis. In addition to these 25 patients, 22 others of the series of 100 cases failed to be relieved and died as a result of the stenosis.

Of 34 cases of cicatricial strictures coming to autopsy in the Pathological Institute of Vienna from 1877 to 1886, death was due in 10 cases to perforation by a bougie; and in 6 other cases to perforation of an ulcer situated above the stenosis. The remainder of the 34 patients died of inanition or tuberculosis. The success of single dilatation by blindly passing bougies with or without gastrotomy may be judged from a report by Ashurst, who records 8 patients treated in this manner. In all of the 8 patients an unsatisfactory outcome resulted. The paper forcibly illustrates the necessity for more accurate and radical treatment.

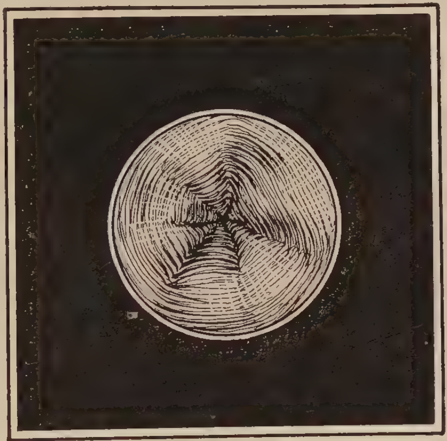


Fig. 9.—Cicatricial Stenosis of the Esophagus.

Treatment.—Benign stenosis of the esophagus is, therefore, a serious condition, progressing steadily and fairly rapidly to death, and demanding a form of treatment suited to each patient. Therapeutically, the patients may be divided into 3 classes:

STENOSIS REQUIRING DILATATION ONLY.—First, patients with beginning stenosis or thin membranous strictures. In this class come all those patients in whom dilatation can easily be accomplished by bougies or graduated olives. In dealing with patients of this first class—and certainly with all others—it is far safer to practice the first dilatation through the esophagoscope.

STENOSIS REQUIRING INTRA-ESOPHAGEAL OPERATIVE PROCEDURE.—The second class of patients are those with whom it is desirable to employ, in addition to simple forcible dilatation, some means for directly attacking the scar tissue. While it is undoubtedly true that perhaps the majority of patients of this class may be successfully treated by forcible dilatation alone, yet even in these cases recurrences are frequent, and repeated stretching is necessary unless some intra-esophageal operative procedure is adopted for dealing directly with the scar tissue.

The operative procedures in this second class of patients may be as follows:

(1) internal esophagotomy, and (2) intra-esophageal electrolysis. Both of these procedures have given excellent results.

INTERNAL ESOPHAGOTOMY.—Internal esophagotomy has been successfully practiced by von Hacker, Guisez, Sencert, Jackson, Starck, and Hill. The technic of this form of treatment, however, has been best defined by Lerche, who has devised a very satisfactory esophagotome for internal esophagotomy (Fig. 13). The lumen leading through the stricture is first identified through the esophagoscope, then slightly dilated by passing through it as many of the series of graduated bougies as can be made to slip through easily. The esophagotome is then inserted, opened up, and placed in such a manner that the cutting blade will divide the portion of the stricture containing the largest amount of scar tissue. Figure 10 represents Lerche's esophagotome. The cutting blade of this instrument is so arranged that the tissues will be divided to a depth of only 1 to 1.5 mm. in a child, and 2 to 3 mm. in an adult. After such a division, the stricture may be quickly stretched to admit one of the larger bougies, 10 mm., at least, in diameter. After an interval of a week to 10 days, bougies or olives should be passed again, and perhaps once again after another similar interval. While it still will be necessary for the patient to remain under observation, and while this method of treatment may not guarantee a permanent cure, yet recurrences after it are far more rare than when dilatation alone is practiced. Lerche has reported excellent results in all of 5 cases treated by this means. In 4 of these cases the strictures may be said to have belonged to the impermeable class.

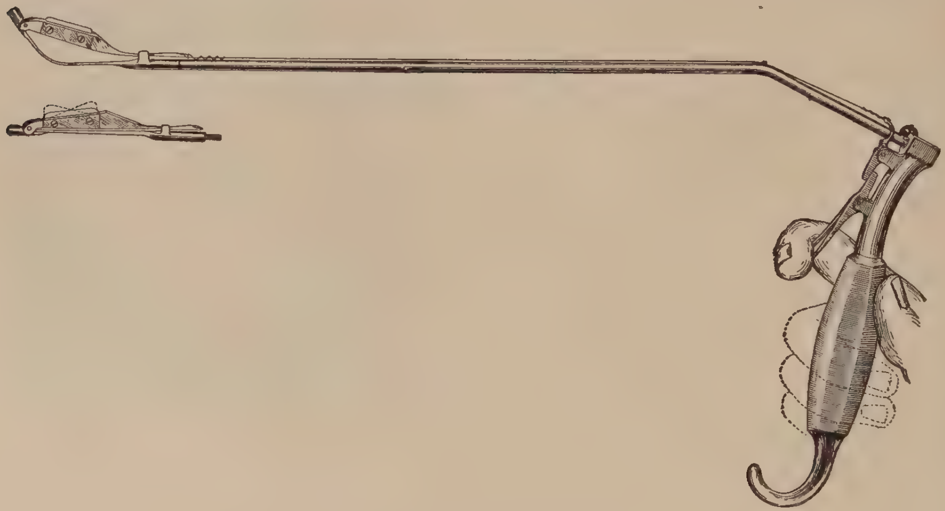


FIG. 10.—LERCHE'S ESOPHAGOTOME.

Another form of internal esophagotomy is known as the Abbe string method. It was devised by Dr. Robert Abbe for the treatment of impassable strictures. The method consists in performing gastrostomy, through the opening of which, with the air of a filiform bougie which is passed from below upward, a string is drawn upward from the stomach into the mouth. By pulling the string backward and forward the stricture may be sawed through. The case which Dr. Abbe reported was very successfully treated by this method.

Peterson and Hartwell also have each reported a patient successfully treated by this method.

Internal esophagotomy has given good results; nevertheless, the procedure is not devoid of danger, and for this reason I believe that it is desirable to consider the treatment of cicatricial stenosis of the esophagus by electrolysis. In a certain class of patients with thick indurative stenoses it is an efficient method of treatment and not accompanied by certain risks incidental to internal esophagotomy. There can be no doubt that electrolysis produces a peculiarly beneficial dissolving effect on scar tissue.

Guisez advocates electrolysis for the cure of cicatricial stenosis of the esophagus as the method of choice. His experience in the treatment of esophageal lesions has been very large and for this reason alone the procedure which he advises as the method of choice deserves serious attention. He reports 34 cases treated in this manner. Of these, 28 were cured. Upon 9 of the patients a gastrostomy had been performed. The majority of the patients suffered from an absolute dysphagia. Five of them were infants. Of the 7 who were not cured, 1 was improved; and in 1 case it was impossible to overcome the obstruction. Four of the patients died, but in only 2 could that outcome be considered a consequence of the treatment.

The technic of the electrolytic treatment of benign stenosis of the esophagus is as follows: The esophagoscope is introduced to the site of the stricture and the orifice of the canal leading through the stricture is sought for. When this has been identified, an attempt should be made to pass a small olive through the stricture. In many cases this attempt easily succeeds and it is even possible to dilate the stricture by passing several larger bougies through it. In other cases only a small filiform bougie will pass and it may even be difficult to locate the lumen. Frequently attempts to dilate the stricture will fail, or if such attempts are persisted in they will only serve to stretch the esophagus at the site of the stenosed portion. Some initial dilatation up to at least 6 or 8 F. is usually possible. After this has been accomplished, an electrolytic olive should be selected, of a little larger size than will just slip through the stricture. The electrolytic olive is of pure nickel or copper. It is attached to the negative pole and passed to the stricture until it engages the lumen. A current of 10 to 12 milliampères is turned on and by gentle pressure the bougie is passed through the stricture. Four to six minutes should be occupied by this process. After the olive has been passed, the stricture will easily yield to bougies six or seven sizes larger. Guisez is firmly convinced that electrolytic dilatation in this manner leads to absorption of scar tissue and to far more permanent results.

STENOSIS REQUIRING GASTROSTOMY.—The third class of patients comprises those in whom gastrostomy is necessary. Guisez estimated that at least

95 per cent. of esophageal stenoses are curable without gastrostomy. In a small proportion of patients with cicatricial stenosis it is impossible to pass the smallest filiform through the stricture, even with the aid of the esophagoscope. In this emergency gastrostomy is demanded. Its performance diminishes the muscular spasm about the stenosis and the inflammatory swelling above it. The improvement is frequently so great that it may be possible to pass the filiform from above after the gastrostomy has been performed. If, however, this cannot be done, it is often possible to pass it from below upward. Once a filiform has been passed, a beginning dilatation may be secured by passing other bougies upon it or upon a thread pulled up by the filiform bougie. Complete dilatation may then be obtained by either internal esophagotomy or by electrolysis.

Conclusions.—The consideration of the treatment of benign stenosis of the esophagus should not be concluded without emphasizing the necessity for the exercise of the greatest care when passing bougies through a cicatricial stenosis. Perforation of the esophagus has been observed by me on two occasions when I knew that the greatest care had been employed. These instances have been so impressive that I feel obliged to express the belief that the above statistics do not convey a true idea of the mortality resulting from attempts to stretch a benign stenosis. It is a wise precaution to start the dilatation upon a previously swallowed thread as a guide. If a patient cannot at first swallow a string, he may be able to do so after a gastrostomy or through the gastrostomy opening a retrograde passing of a filiform bougie may succeed. In the event of the failure of these procedures the future may demonstrate the wisdom of attempting the treatment of the worst forms of cicatricial stenosis by exposing the site of the stenosis through a thoracotomy wound before proceeding with the dilatation.

CONGENITAL STENOSIS

Congenital stenosis of the esophagus is another form of benign stenosis of considerable interest but of very rare occurrence. According to Zeit, its existence depends upon abnormal development of the lateral ridges which, growing inward, separate in fetal life the esophagus from the trachea.

The following classification is given by Griffhorn:

1. Complete lack of esophagus.
2. Complete or partial closure of esophagus at a variable distance from teeth.
3. Dilatation or double esophagus.
4. Abnormal position of esophagus, *situs inversus*.
5. Simple communication with the trachea.
6. Communication of trachea with an esophagus ending blindly below level of communication.

The last-named is the most common variety. I have, however, seen one of class No. 2. There was not, in this case, a complete closure of the esophagus. A pin-point opening was discovered in the lower third, which barely admitted a filiform bougie. (See Figure 11.) Safe dilatation was impossible. Operative treatment—at least an exploratory thoracotomy—was indicated, but consent for such a procedure was not obtained.

BENIGN TUMORS

Benign tumors of the esophagus are so rare that they will always be classified as medical curiosities. Mackenzie reported a polyp in 1881 (*Medical Times and Gazette,* 1881, ii, 60). Their diagnosis with the esophagoscope is a simple matter if their presence is suspected early enough for the region of the esophagus beyond them to be inspected. Usually, however, they do not cause symptoms unless they obstruct the lumen. In this case it may be impossible to differentiate benign tumors of the esophagus from malignant new growths, except by the removal of a small piece of the tumor for microscopical examination. The most valuable diagnostic feature of benign tumors, which generally belong to the class of myomata, is their pedunculated character. If this is clearly demonstrable, the true nature of the growth may be suspected and the whole tumor may be snared off.

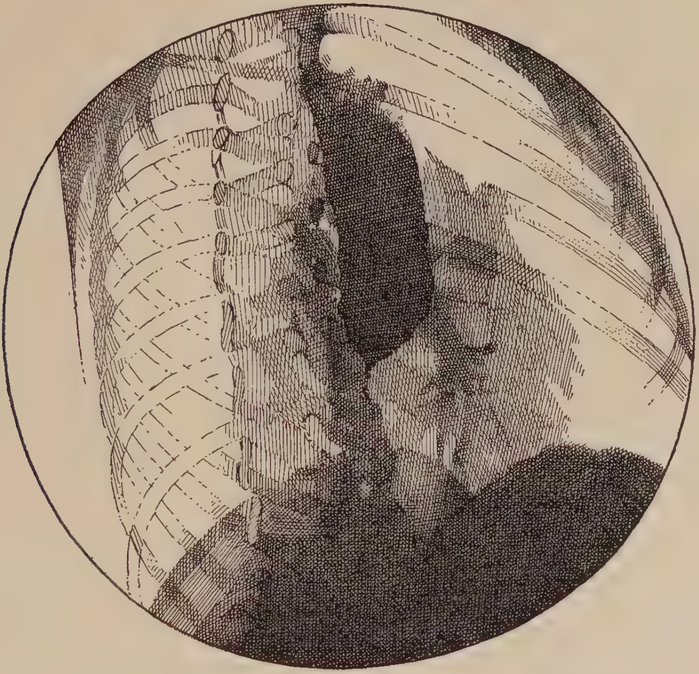


Fig. 11.—Radiograph from a Child of 8 Years with a Congenital Stricture of the Esophagus.

MALIGNANT NEW GROWTHS

By far the most frequent of the esophageal diseases is cancer, and cancer of the esophagus is seldom other than epithelioma. Starck has collected 7 examples of sarcoma from the literature and described 2 himself. Von Eichen added 4 others, 1 of which he examined with the esophagoscope. Although it presented the appearance of a phlegmonous inflammation, its true character was proved by the microscopical examination. Von Hacker reports 2 cases of sarcoma of the esophagus; of 1 of these he made a diagnosis by a biopsy. He also collected 21 cases from the literature. In 17 of these the growth was in the thoracic portion. The tumor was hard in some instances, in others it was soft. In one of his own cases the sarcoma started as a pedunculated tumor, which spread rapidly, presenting, as it increased in size, a nodular ulcerated surface.

The occurrence of cancer within the esophagus forms in itself a sufficient reason for esophagoscopy. Cancer of the esophagus can be recognized in its earliest stages only by esophagoscopy. Every esophagoscopist sees patients with cancer of the esophagus who have been allowed to go without a diagnosis until 3 months to a year from the date of their first symptom—in other words, just as long as they would tolerate the condition.

Of 25 cases of epithelioma of the esophagus recently examined by me, only 2 were referred for examination within 3 months from the time of their first symptoms. A number of the patients were not examined until a year from the date of their first symptoms. The accompanying illustration (Fig. 12) shows an epithelioma of the esophagus which was not discovered until autopsy. The diagnosis before death was empyema. The abscess in the lung due to perforation of the epithelioma was the only lesion detected before death. Recently Cabbot has reported the diagnostic errors among 3,000 patients coming to autopsy. In this contribution the mistakes in the diagnosis of cancer of the esophagus were more frequent than those of any other disease.

Appearance Through the Esophagoscope.—Every patient complaining of esophageal symptoms (particularly of a little difficulty in swallowing) should be advised to have an esophagoscopic examination. In cases of esophageal cancer, a diagnosis is easily possible upon the appearance alone. The appearance that I consider most characteristic is the presence of one or more polypoid, though not truly pedunculated, masses, varying from the size of a small pea to a walnut, within the neighborhood of the tumor. These masses are usually deep red in color and bleed upon slight provocation. Often they are small, and form, so to speak, outposts of the main body of the tumor. Aboral to them is the real stenosis, and any attempt to enter the same is accompanied by considerable hemorrhage. Again the masses are merely the borders of a cauliflower ulcer, one edge of which alone is visible. The surface of these masses, and often the mucous membrane at their base, is ulcerated and covered with flakes of exudate, necrotic tissue, and desquamated cells. Not all cancers present this appearance. At times the esophagoscope cannot penetrate to the real ulcer; but the induration extends upward, beneath an apparently healthy mucous membrane, producing a stenosis above the ulcerated area. Though histologically the epithelium in this class of cases is normal, indication of the infiltration beneath it can be detected through the esophagoscope. It is paler than the normal mucosa of the esophagus and often is not entirely smooth. Its surface may be covered with small pale elevations between which the membrane is darker. This surface is unyielding and bleeds easily as the end of the esophagoscope or a sound is pressed upon it. (See Fig. 13.)

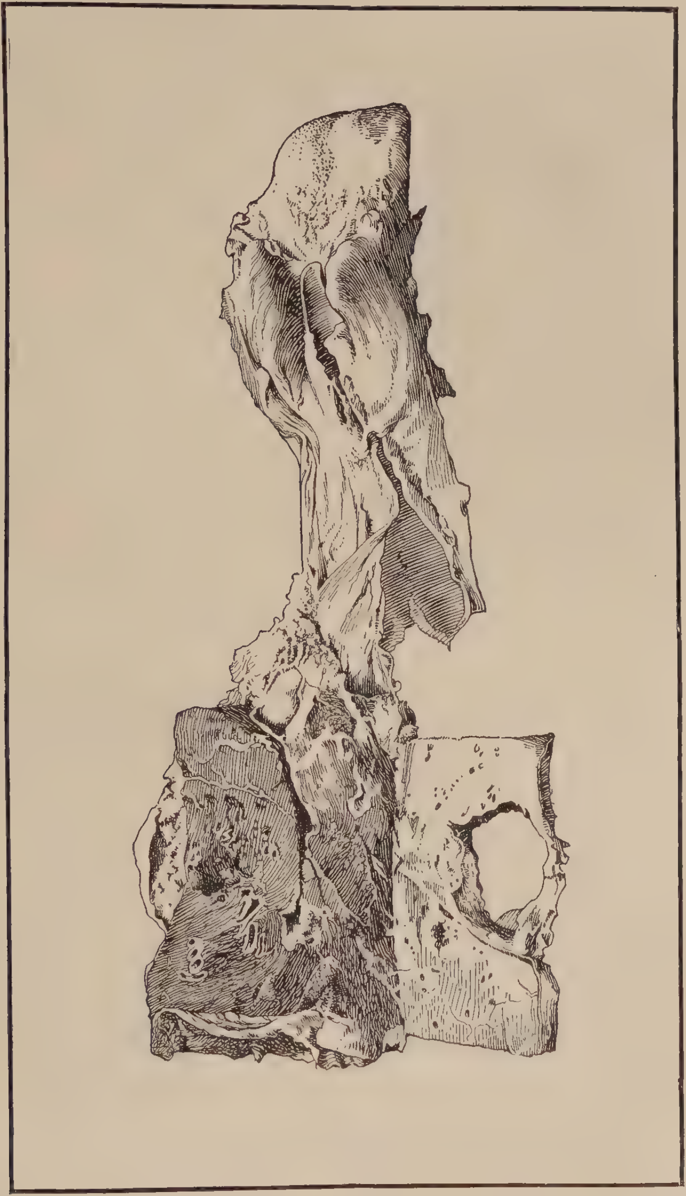


Fig. 12.—Autopsy Specimen of Cancer of the Esophagus Not Diagnosed During Life, and Section Through a Pulmonary Abscess Cavity Secondary to It.

Induration is a feature of all cancers of the esophagus. The walls in the immediate neighborhood of a cancer are immovable. The normal respiratory excursions of the esophageal walls are entirely absent, and the impulse from the aorta is usually missed. The summits of all the small elevations in the carcinomatous area are pale and contrast strongly with the bleeding or inflamed base around them and with the usually congested mucous membrane in the neighborhood. The tumors, during the various stages in which they are presented for examination, vary much in size and extent and in their manner of spreading. Almost all possibilities are present. They may form ring-like constrictions with much stenosis, although of very small size themselves, or they may show a marked tendency to spread over a long distance of the esophagus, deeply infiltrating its walls. Here and there the tumor growth breaks through, giving rise to small elevations or papillomatous projections. Another class infiltrates deeply without much superficial spreading. Usually a tumor gives symptoms before the wall of the esophagus is penetrated, and the tumor becomes adherent to the surrounding structures.

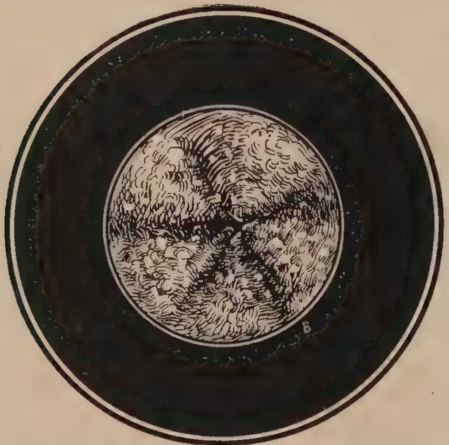


Fig. 13.—Cancer of Cervical Portion of Esophagus.

Starck has described various types of appearances which, in general, correspond fairly well with those described above.

INFILTRATING EPITHELIOMA.—In this form the wall is densely infiltrated, rigid, and immovable. It may not be possible to get down to the growth itself with the esophagoscope. The mucous membrane over the growth is usually pale, anemic, and may even be smooth. There is absolute loss of all movement of the esophagus during respiration and to the impact of instruments passed through the esophagoscope. Fig. 13 illustrates the condition often found.

ULCERATED CANCER.—Many growths are characterized by a strong tendency to bleed and by much simple ulceration of the infiltrated mucous membrane surrounding the tumor. The ulcer is almost always associated with more or less necrotic, foul-smelling slough. (See Fig. 14.)

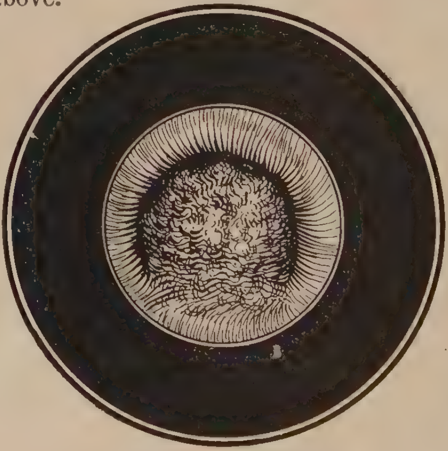


Fig. 14.—Cancer of Lower Third of Esophagus.

POLYPOID TYPE.—A third type might be termed the polypoid type. It is the "wandständige" tumor of Starck. In this type there is a progressive involvement of the walls of the esophagus, with the superficial spreading characterized by polypoid tumors of varying sizes which represent the outcropping of the extensions of the tumor. The individual tumors may be smooth as a grape upon their surface, or as uneven as a raspberry. They often appear pedunculated, but really are not so. A closer examination of their bases shows them to be connected by broad attachments with other masses below them. These tumors may occupy only one portion of the circumference of the esophagus. The lumen of the latter is pushed to one side and appears as a crack or crescentic slit. This is especially the case in the youngest growths. Fig. 15 well illustrates the appearances often present.

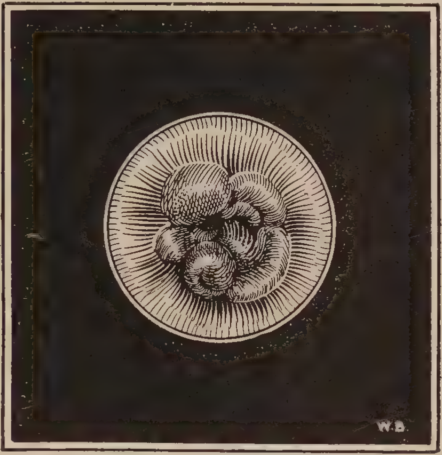


Fig. 15.—Cancer in Lower Third of Esophagus.

RING-LIKE STENOSIS.—The last form is the ring-like stenosis. In this form the tumor seems to be of slow growth and involves only a short length, 2 to 3 cm., of the esophagus. It is circularly disposed and soon produces a stenosis. This type resembles in some respects the benign stenoses. It is usually possible to make out the ulceration or a peculiar uneven nodular character to the surface which suggests cancer. Tissue removed from the surface shows cancer upon microscopical examination.

Starck, von Mikulicz, and others have commented upon the difficulty of diagnosing cancer of the cervical portion of the esophagus. I have not experienced this difficulty, although I have had opportunity to examine a considerable number of cases. I believe that the explanation lies in the use of the obturator while introducing the esophagoscope. Von Mikulicz on one occasion perforated an esophagus in the attempt to introduce an esophagoscope with the aid of an obturator. An experience of this character demonstrates the wisdom of inspecting every portion of the esophagus traversed by the esophagoscope.

SECONDARY GROWTHS.—It must not be forgotten that many new growths of the lower extremity of the esophagus are really gastric tumors which have involved the esophagus secondarily. The microscopical examination of these tumors will show carcinoma and not epithelioma. In such instances we are dealing with a much more extensive growth than might be expected from similar appearances presented by tumors which are primary within the esophagus. In general, these tumors present the same characteristics, when viewed through the esophagoscope, as the primary esophageal epitheliomata.

Treatment.—The treatment of esophageal cancers through the esophagoscope offers little for discussion, aside from the possibilities of affecting them favorably with radium. Unquestionably, dilating the strictured area through the esophagoscope will diminish the dysphagia and add materially to the patient's comfort for many weeks. I have been surprised to find that many patients have been greatly relieved in this particular by the esophagoscopic examination alone, although no particular pains were taken to dilate the stricture. The passing of an esophagoscope merely down to a malignant stricture will often give relief from dysphagia for weeks. It is of the utmost importance to avoid forcible efforts in dilating malignant strictures. Gentle efforts are all that are required to afford the majority of patients relief and there is serious danger of splitting the esophagus in the use of greater force.

Permanent intubation has not offered any advantages. The intubation tube easily becomes displaced or occluded.

RADIUM TREATMENT.—The treatment of inoperable cancer by radium offers some promise for the future. At the present time the responsibility of its use in case of operable growths should be shared by the patient. Even though operations for cancer of the esophagus are accompanied with such grave risks, no form of operable cancer should be treated by radium in preference to resection unless it is understood by the patient that success by such treatment is problematical.

Although no guarantee of success can accompany the use of radium, much encouragement comes from the reports of such experiences as those of Hill and Guisez, which cannot be ignored as unimportant. Esophageal cancers almost always give symptoms before metastases have occurred. My experiences have convinced me that radium will cure early malignant new growths. If the radium is to accomplish any good, however, it is necessary to apply it in sufficient dosage and properly filtered. The patient which Hill has reported was treated with 50 mg. of pure radium bromid for 13 hours, and, 2 months later, for 21 hours. Following this treatment, there was a progressive improvement until swallowing became normal. A subsequent esophagoscopic examination demonstrated an entire absence of any lesion of the esophagus. The diagnosis in this case had been established, before the treatment had been undertaken, by an esophagoscopic examination and microscopical section of a bit of tissue removed at this time. The growth was situated 28 cm. from the teeth. There had been increasing dysphagia and odynophagia for the preceding 6 months.

Guisez reports 26 cases of cancer of the esophagus treated by radium during the past 4 years. He believes that the slowly growing, less ulcerated forms are very susceptible to this method. He publishes the details of 3 patients in whom the improvement was very remarkable. He uses 5 cg. of radium inclosed in a silver capsule and applies this interruptedly for a total radiation period of 30 hours, divided into periods varying from a quarter of an hour to several hours' duration. In appropriate cases there has been a rapid restoration of the lumen of the esophagus.

Lauper reports an apparent cure of a patient in whom the diagnosis was confirmed by microscopical diagnosis. He applied only 3 mg. of a preparation of 500,000 activity for from 8 to 45 minutes 3 times weekly.

In my experience, the most important factor in success is the knowledge of what constitutes the correct therapeutic dose of the preparation used.

DIVERTICULA

The esophagoscope has not the same field of usefulness in the diagnosis of diverticula as in the diagnosis of other intra-esophageal lesions. While there is no lesion of the esophagus whose nature it is more important to appreciate correctly than diverticula, yet other methods of diagnosis are more convenient than esophagoscopy. Particularly is this true of sounding by the Plummer method and of the X-ray diagnosis. The shadows of diverticula usually come out with great clearness.

Two kinds of diverticula present themselves for consideration: the pulsation diverticula and the traction diverticula.

Pulsation Diverticula.—The pulsation diverticula almost invariably open into the esophagus at the junction of the pharynx and esophagus. The esophagoscope usually will enter the diverticulum. Beneath the opening into the latter is a valve-like protrusion, generally opposite the cricoid cartilage, which facilitates the entrance of the esophagoscope into the diverticulum. The opening into the diverticulum is, as a rule, wide, but sometimes it is contracted and presents an appearance somewhat like the anus; at other times it is cleft-like. The esophagoscope passes through this opening and comes to the bottom of the sac. It here meets an impassable obstruction which gives no indication of the further extension of the esophagus. Often the mucous membrane at the bottom of a diverticulum is much eroded and inflamed. It is not unusual to see folds of the mucous membrane within the sac. The normal respiratory movements of the esophageal wall are absent.

If, now, the esophagoscope is withdrawn and its distal end directed well forward, the lips dividing the diverticulum from the esophagus proper will suddenly slip across the opening of the instrument. It may be impossible to pass the esophagoscope in front of the lip and down the true esophagus. In about half of the cases this forward insertion cannot be accomplished, since the entrance to the esophagus may be concealed. In other cases it is possible to see the partition between the esophagus and the diverticulum, though it is not possible to pass the esophagoscope in front of it. Very often the opening into the esophagus is revealed by the bubbling up of aspirated air and the vomiting or regurgitation of small amounts of fluid. The difficulty of entering the esophagus seems to be in proportion to the size of the diverticulum.

Whatever the method of diagnosis, the recognition of diverticula is, in general, more difficult during the early period of their development. In these cases the diverticulum is simply a hernial protrusion of the pharyngeal wall. Usually the septum between the diverticulum and the esophagus is pronounced and in early cases can easily be seen by the aid of the esophagoscope, though occasionally there is difficulty in distinguishing it from a simple fold of mucous membrane. If the esophagoscope can be introduced into a pocket, the distal wall of which fails to fall away continuously from the instrument and also fails to show a dimple-like lumen, we are dealing with a diverticulum. The color of the mucous membrane of the sac is, also, much darker or more bluish red than that of the normal pharyngeal walls.

Attempts to treat diverticula through the esophagus by stretching the upper border of the threshold of the diverticulum downward are not recommended. Though this plan of treatment may be accomplished readily in early lesions, there are few patients for whom surgical treatment is not more appropriate.

Traction Diverticula.—Diverticula originating below the entrance to the esophagus (thoracic esophageal traction diverticula) are much rarer than the pharyngo-esophageal, the typical Zenker's, diverticula. The former spring from any portion of the circumference of the esophagus, though they more frequently grow from the anterior wall. Diverticula of this variety, examined by the esophagoscope, have been described by Kelling, Landauer, and Rosenheim. These diverticula probably start as traction diverticula.

The vast majority of the thoracic traction diverticula are of small size and cause no symptoms; they are found only accidentally or at autopsy. Occasionally, however, they are of large size. One has been described by Kelling as reaching to the cardia and possessing a capacity of 300 c. c., and that described by Landauer possessed a depth of 40 cm. from the teeth. That of Rosenheim was 3 cm. deep from its slit-like opening, which was 37 cm. from the teeth. It produced dysphagia. In this variety of diverticulum an attempt may be made to treat the condition through the esophagoscope by breaking down the partition wall between the esophagus and the diverticulum. A clamp made in such a manner that it could be put upon the wall and left in situ until it had caused necrosis could be tried in these cases.

DILATATIONS OF THE ESOPHAGUS

Dilatation of the esophagus is caused by a variety of lesions which are usually the result of obstruction. They complicate cancer and benign stenosis. The most interesting form of diffuse dilatation of the esophagus is one which may be accompanied with no demonstrable anatomical lesion and which is generally attributed to spasmodic contraction of the esophagus. Stenosis of the esophagus of a spastic character may occur either at the entrance of the esophagus or at the level of the aortic and bronchial constriction of the esophagus or at its lower extremity. A number of cases have been described as located at the cervical constriction of the esophagus, and they are not so rare as might be expected. I have seen at least 2 cases, the appearance of 1 of which is illustrated in Figure 16. It shows merely a convergence of the esophageal folds to one central dimple. The condition and its esophagoscopic appearances differ in no manner from the appearance of the normally closed esophagus. After the application of cocain, the obstruction yields readily to pressure of the esophagoscope—so readily, indeed, that, were it not for the symptomatology of the case, doubt might exist as to the true nature of the patient's complaint. As in benign stenosis, no scars are present in the mucous membrane of the esophagus.

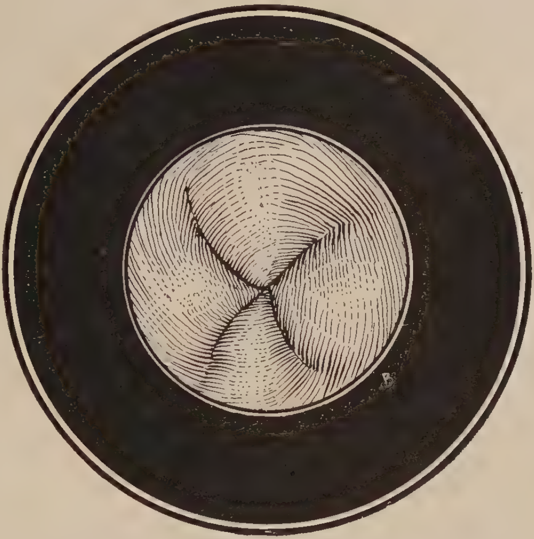


FIG. 16.—SPASMODIC STRICTURE AT ENTRANCE OF THE ESOPHAGUS.

Cardiospasm.—The cardia is by far the most frequent location for spasm of the esophagus. Occurring in this location, the condition has received the name of cardiospasm. It is accompanied by a typical symptomatology and by a diffuse dilatation of the whole organ.

APPEARANCE THROUGH THE ESOPHAGOSCOPE. — Examined by the esophagoscope, the increase in the size of the lumen becomes readily apparent. Instead of coming together with respiration concentrically in front of the esophagoscope, its walls flap loosely together at each expiration, almost like the two sails of a vessel. (See Fig. 17.) Often some difficulty is encountered in obtaining a good view of the esophageal walls. At one moment they are widely separated from the end of the esophagoscope, and the next minute one wall or the other closes over the end of the tube. When separated, the end of the esophagoscope appears to be in the center of a dark hollow cavity. Often there is evidence of inflammation of the mucous membrane. The esophagoscope finds the bottom of the esophagus with surprising ease; then the end of the instrument is buried in fluid and the lamp appears extinguished. The amount of fluid contents, even though no food has been taken for some time, is surprisingly great. It is, however, easily sucked out. It is then seen that the end of the esophagoscope is within a fairly large cavity, in which a search must be made for the cardiac orifice. When this is located, it presents much the ap-

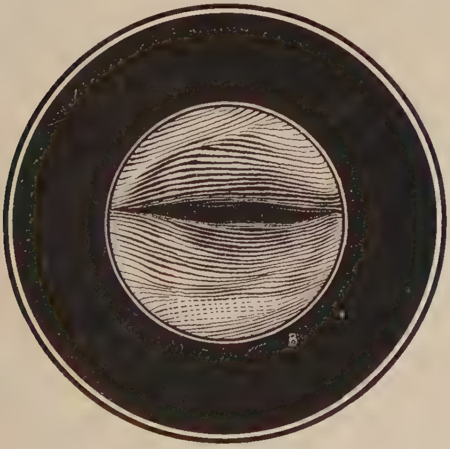


FIG. 17.—APPEARANCE IN DILATATION OF ESOPHAGUS DUE TO CARDIOSPASM.

pearance of the normal cardiac orifice, and usually yields readily to pressure, so that it often seems that no obstruction at all could be present. The orifice, in the vast majority of cases, is readily dilated, but this dilatation does not always effect a cure, because the esophagus above has been dilated so that it forms a sac, the floor of which is on a lower level than the opening into the stomach; consequently, when the sac becomes distended with fluid, the wall of the sac intervening between the sac and the cardiac orifice closes the latter, acting like a valve—thus little or no fluid can be forced through. Dysphagia is one of the most important and constant symptoms of cardiospasm.

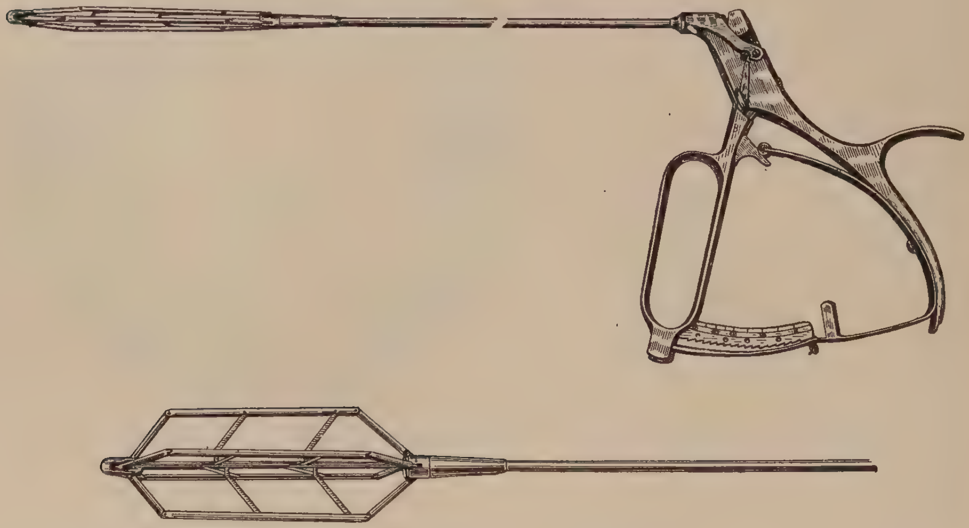


FIG. 18.—INSTRUMENT FOR DILATING A STENOSIS OF THE ESOPHAGUS DUE TO CARDIOSPASM.

These cases bear a great similarity to malignant diseases, though they differ in that they usually run a much slower course. The esophagoscopic examination is of the greatest importance in arriving at a diagnosis. But for its aid, one could not in many instances differentiate cardiospasm from cancer. Furthermore, through the esophagoscope, very successful treatment may be carried out.

TREATMENT BY DILATATION.—Many patients may be cured by simple dilatation. For this purpose the instrument designed by Lerche offers a simple but effective method. I have had it modified and made in 2 sizes, both larger than the original (Fig. 18). Of these sizes, one will stretch the cardia, so that it measures 8 cm. in circumference; and the other, 12 cm. in circumference. With this instrument it is possible to stretch the cardia under sight of the eye. In my experience, one such stretching has often accomplished a cure. One patient who had been unsuccessfully treated by repeated attempts at hydrostatic dilatation obtained a satisfactory result after dilatation with this instrument. It has now been definitely established by the experience of many observers that forcible dilatation of the cardia will accomplish a cure of cardiospasm.

The largest series of cases is reported by Plummer. His method is as follows:

A gum elastic catheter, around which is tied a rubber bag covered with silk, is passed through the cardia. (The silk bag measures 10 cm. long, by 20 to 40 mm. in diameter.) The rubber bag is now dilated by allowing water to run into it at a pressure not exceeding 500 mm. of Hg. A water column 5 to 6 feet high is sufficient. In one of Plummer's cases the esophagus was ruptured by a pressure of 720 mm. of Hg. Many cases are permanently cured by a pressure of only 50 to 100 mm. of Hg. The majority of the patients whom Plummer has treated have been permanently relieved by 1 treatment, although some of his patients needed 5 treatments and two needed 7 and 11 respectively. The intervals between the treatments have usually been from 3 to 4 days. The patient is discharged cured if the esophagus remains free of food remnants at the end of 10 days. In 29 of Plummer's first series of 30 patients there have been no recurrences, and the immediate results have been striking, the patients beginning to eat with perfect comfort. In 1912 Plummer reported a series of 91 cases; of these, 73 were permanently cured of dysphagia; 11 were incompletely cured. Five patients died, 2 from pneumonia, 1 from tuberculosis, 1 from an unknown cause, and 1 from rupture of the esophagus. Of the cured patients, 3 have been well from 6 to 7 years; 12 from 5 to 6 years; 9 from 4 to 5 years; 13 from 2 to 3 years; 12 for 1 year; 10 for less than 1 year.

Of very great assistance in passing the dilator is the dilatation of the sphincter by bougies until it can be made to take the Plummer instrument. Nothing, however, could be more dangerous than to pass these bougies blindly. They should always be passed upon a thread which has been swallowed previously. The technic is as follows: Three yards of No. 6 strong silk, 6 yards long, is swallowed one day, and the remaining 3 yards the next morning. Enough of this thread passes into the intestines to make it possible to draw taut the portion passing through the esophagus. Upon this are passed the drilled olives, screwed to a flexible metal staff. By beginning with small sizes, and then passing increasingly larger sizes, a considerable degree of dilatation may be accomplished. This initial dilatation can be carried further with either the special stretcher mentioned or with Plummer's dilating rubber bag.

Von Mikulicz was the first to permanently cure a patient with an intractable cardiospasm by dilatation of the cardiac sphincter. This was accomplished by the fingers through a gastrostomy opening, as has been already mentioned. The accumulated experience of various surgeons since that time has furnished abundant evidence that forcible dilatation by instruments passed through the mouth will accomplish a cure. Thus, Guisez has cured all of 12 patients by dilatation with the Gottstein balloon dilator. This dilator is very similar to Plummer's, consisting of a silk bag inclosed between 2 rubber bags, the external rubber bag being merely a cover.

Jüngerich reports good results in 4 to 6 cases.

Heyrovsky reports 1 case by the von Mikulicz method of "sounding without end," followed by dilatation with a Gottstein balloon.

Best reports success by stretching upon the Gottstein balloon.

Starck states that success is assured by a dilatation of the cardia twice a week.

Meyer has reported 10 cases, of which 4 of the 6 who submitted to treatment obtained a very satisfactory result. The 2 others were partially relieved. Of the 4 patients who refused treatment, 2 died of inanition.

Einhorn's experience in 1 patient treated with dilatation has been equally successful.

Huber reports 2 patients treated successfully by passing bougies, combined with very careful dietetic treatment.

Albu also reports 1 case cured by systematic dilatation.

Adams reports the occurrence of cardiospasm in a child of 6 months, temporarily cured by the passage of bougies.

DIETETIC TREATMENT.—The dietetic treatment of cardiospasm is by no means unimportant. Every precaution should be taken not to allow the esophagus to become overdistended or to increase the size of the sac-like dilatation above the diaphragm. Food should be taken in small quantities and well masticated if it is not in a soft condition. Large quantities of food or water should not be taken at any one time.

Janczurowicz describes 3 patients cured by dietetic treatment alone. In the same article there is a very complete reference to the literature of cardiospasm.

Brailowskaja also emphasized the importance of careful dietetic treatment and lavage.

OPERATIVE TREATMENT.—Operative treatment has occasionally been recommended and tried for the most resistant cases of cardiospasm. This treatment has included thoracotomy and plication of the esophagus.

Meyer and Rumpel have suggested resection of the cardia.

Jaffé attempted to excise a longitudinal strip from the esophagus.

Gottstein recommended extramucous-cardioplasty.

Wendel accomplished this operation with complete success.

Reisinger, after making a preliminary gastrostomy, has succeeded in plicating the esophagus through the posterior mediastinum of the right side, after the method of approach of Rehn, Nasiloff, and Bryant.

INFLAMMATION AND ULCERATION OF THE ESOPHAGUS

Simple Inflammation.—Acute inflammation of the esophagus frequently follows the swallowing of caustic alkalies or acids, etc. It is sometimes found in connection with acute infectious diseases, especially diphtheria. These cases should never be examined with the esophagoscope. Localized areas of acute, subacute, and chronic inflammation of the esophagus may be associated with the lodgment within or passage of foreign bodies through the esophagus. Cancer of the stomach or esophagus may also be accompanied with esophagitis. Disintegration of food within a dilated esophagus or within the sac of a diverticulum may cause subacute or chronic inflammation of the esophagus. Of more interest than these inflammations, however, is the occurrence of a peptic ulcer or a syphilitic ulcer, or tuberculosis or actinomycosis of the esophagus. The possibility of the existence of any of these lesions must always be borne in mind.

Peptic Ulcers.—Peptic ulcers in the esophagus are rare, although frequent enough to warrant careful study. They present all the characteristics of simple ulcerations. They usually occur below the hiatus of the esophagus and not infrequently are associated with hyperacidity and probably depend in a measure upon the invasion of the lower end of the esophagus by the acid contents of the stomach. They may also be associated with ulceration of the stomach. Single ulcerations of the esophagus may also be caused by typhoid fever. The true nature of these single ulcers is not always easy to determine.

Gottstein has reported 2 patients with peptic ulcers of the esophagus, and Starck 1.

Guisez and Abrand report 9 patients who had peptic ulcers of the esophagus; of these, 7 were women and 2 were men. In 1 of the patients, the esophagoscopic appearances revealed an ulcer 4 to 6 mm. by 8 to 10 mm., with a pale areola in which, however, visible vessels were present. The ulcer was not deep; the base was granular and of only a slightly darker color than the area around. The symptoms of this condition closely resemble those of gastric ulcer.

Miller, Sencert, Watson, and Broca, all report perforations of the esophagus from peptic ulceration. Kappis and Cantieri report other cases.

Syphilitic Ulceration.—Syphilitic ulceration in the esophagus is very rare. Gottstein has reported 1 case, and Guisez, 2 cases. Out of 5,000 tertiary lesions Fournier has found only 4 in the esophagus. Starck considers that syphilis of the esophagus is exceptionally rare. Downie and Jackson, on the contrary, believe that it is much more frequent than is commonly supposed. Chevalier Jackson also states that it is frequently overlooked.

Tuberculous Lesions.—Tuberculosis occurs in the esophagus. As much as 4/5 of the esophagus has been known to be involved without an esophageal lesion having been suspected. It may be secondary to tuberculosis of the cervical vertebræ or of the larynx or lungs. It is not infrequently a continuous extension of disease primarily involving the larynx. Dr. Jackson has met with many cases where the dysphagia and odynophagia were attributed entirely to the larynx. Local treatment affords these cases little relief. Gardère has collected 70 cases from the literature. He classified them into 3 subdivisions: (1) the ulcerative forms; (2) sclerotic hypertrophied forms; (3) perforative forms.

In the *ulcerative form,* the disease usually attacks the median third of the esophagus. There may be many small ulcers or coalesced lesions, together forming areas 10 to 15 cm. long. The border is irregularly eroded. The base is deep, uneven, granular, pale gray, and usually presents caseating yellowish points.

In the *sclerotic form,* the esophagus becomes transformed into a rigid indurated tube. The new tissue involves the mucous and submucous coats, while the lesion is easily confused with simple stricture.

In the *perforative form,* the esophagus is usually attacked secondarily from an adjacent lymphatic gland. The perforation is from outward within. The esophagus is attacked probably only 3 times in 10,000 cases of tuberculosis of the lungs. Guisez and Abrand report 2 cases, in 1 of which the diagnosis was made ante mortem. Moure, Viel and Schrotter each report 1 case.

NEUROSIS OF THE ESOPHAGUS

A number of patients must be classified as being afflicted with esophageal neurosis. Such patients complain of a peculiar subjective symptom, referable to the esophagus—a vague feeling of itching, burning, or crawling. Sometimes it is described as a sensation of a foreign body. An examination reveals no anatomical basis for these symptoms. This examination is very important with these patients, as not infrequently an anatomical basis such as cancer may cause precisely the same symptoms. In others, there may be an ulcer at the lower end of the esophagus, or a beginning diverticulum, or actually a foreign body which may have been swallowed unconsciously. In fact, the use of the esophagoscope has gradually diminished the number of true neuroses. In the absence of any definite cause, the treatment must be the same as that for hysteria.

PARALYSIS AND PARESIS OF THE ESOPHAGUS

The motor power of the esophagus may be deficient or absent because of paralysis of the vagus nerve. This may be paralyzed as a result of central bulbar lesions, or from peripheral neuritis, as after alcoholic or lead paralysis. A dysphagia is complained of, which will lead the surgeon to expect to find some obstructive lesion, whereas, upon examination, quite the reverse condition

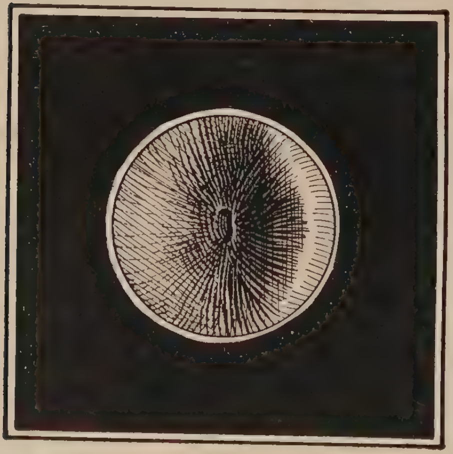


FIG. 19.—APPEARANCE OF CARDIAC ORIFICE IN A PATIENT WITH BULBAR PARALYSIS.

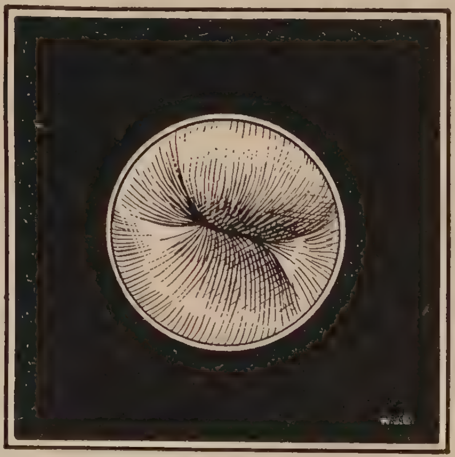


FIG. 20.—APPEARANCE AT THE LOWER THIRD OF ESOPHAGUS IN A CASE OF PARESIS OF ESOPHAGUS SECONDARY TO BULBAR PARALYSIS.

will be revealed, the esophagoscope readily entering the esophagus and easily passing its entire length. The treatment of this condition is constitutional. Figures 19 and 20 represent the esophagus of a patient with bulbar paralysis.

FOREIGN BODIES IN THE ESOPHAGUS

Diagnosis.—The esophagoscope has performed its most conspicuous service in the diagnosis and removal of foreign bodies in the esophagus. For the knowledge of a foreign body within the esophagus—aside from the esophagoscope—the surgeon can depend upon the history of the case, upon touching the foreign body with a sound introduced within the esophagus, and upon an X-ray examination. The history is often unreliable. Many patients feel certain that they have swallowed a foreign body when such is not the case. In others, who actually have swallowed a foreign body, the object may have passed on, leaving sensations referable to the esophagus which produce the impression in the patient that the body swallowed is still within the esophagus. Among children, there may be no history at all of the deglutition of a foreign body. The little patient may be brought to the physician suffering from attacks of coughing or vomiting (regurgitation). Strangely enough, all observers have agreed that even the X-ray has failed at times to reveal the presence of a foreign body within the esophagus, although I believe that this can happen only upon rare occasions. With the present-day perfection of the X-ray, it is difficult to believe that such an error is possible, unless the foreign body is soft as cotton, or very translucent to the X-ray, as may be the case with some pits or seeds.

There is a general agreement that the use of sounds for the recognition of a foreign body is not only dangerous but that it is extremely uncertain. There is no longer an excuse for their use, or for the use of bristle probangs or coin catchers. All these instruments have not only frequently failed to extract foreign bodies, but on rare occasions have caused perforations.

Removal Through the Esophagoscope.—After the radiograph has been taken an attempt should be made to remove the foreign body through the esophagoscope. During this operation, every portion of the tract should be examined, including the back of the pharynx, both pyriform sinuses, and the entrance to the esophagus. It has not infrequently happened that a foreign body has been dislodged or been passed by the esophagoscope in the attempt to first see the object in the assumed location.

Foreign bodies are easily recognized through the esophagoscope. Coins shine out vividly, although occasionally, if they have remained a long time in the esophagus, they may be embedded in folds of mucous membrane, or be surrounded by an inflamed area which may make their recognition more difficult. Once discovered, they can easily be extracted with an appropriate pair of forceps. Open safety pins are the most difficult bodies to extract. These may be closed by an instrument designed by Mosher—consisting of a horizontal ring attached to a staff. The ring is passed over the head of the pin. Then a long hook is passed through the ring of the pin, and the pin is pushed or pulled, according to the direction in which it points, and thus closed. It may then be easily extracted. Up to the time of the publication of Starck's book, he was able to collect 73 cases of foreign bodies, of which all but 5 per cent. were successfully dealt with by esophagoscopy. He compares this to the statistics of 217 cases of external esophagotomy for foreign bodies, of which 20.93 per cent. died.

No rules can be given for the extraction of foreign bodies by the esophagoscope. For each individual case, special technic must be employed. The simple forceps will be found useful for a majority of bodies. It may be necessary to guide the body into the stomach. Dr. Jackson in this manner has 5 times successfully removed safety pins which were lodged in the esophagus with their points directed upward. Through the esophagoscope, the pin is caught at the eye by the forceps or hook, pushed down into the stomach, rotated, and pulled upward. If the body is pointed or actually sticking into the esophageal walls, it must be seized and so rotated that the pointed end can be extracted last. It may be necessary to cut large bodies into small pieces for extraction. Von Mikulicz invented an instrument for this purpose.

Many times it may be possible to pass a ring—horizontally fastened to a stem—below the examining esophagoscope. By withdrawing the ring slightly, the body may be engaged between the ring and the end of the esophagoscope, and thus extracted.

Special instruments may sometimes be needed which are capable of engaging a foreign body, just as a bladder stone is seized for crushing. One of the most frequently lodged of foreign bodies is the plate of false teeth. Often, these present considerable difficulty, particularly if they have been lodged in the esophagus for any length of time. This difficulty depends upon inflammatory reaction around the body, upon spasm excited by its presence, and upon the size and irregular shape of the body. Forceps possessing hook-like pins will often secure a firm hold upon the plate. A wire loop in the form of a snare may often be passed around the body, securing a very firm hold. This wire should be thin enough to break easily in case it is found necessary to secure a new hold. Irregular pieces of bone, which form a large percentage of the foreign bodies lodged within the esophagus, present many of the same difficulties that are encountered in removing plates of teeth, and are to be dealt with in much the same manner.

Local anesthesia and adrenalin will do much to aid in the elimination of the local spasm of the esophagus and contraction of the inflamed area. Guisez has devised a special speculum, the end of which hinges open and, in his opinion, facilitates the dislodgment of the impacted foreign bodies from within the esophagus. He reports 3 cases in which he has used it with success.

Mortality.—In 1911, Dr. Jackson collected from the large clinics 616 esophagoscopies for foreign bodies, with a mortality of 3 per cent. The percentage obviously represents skillful work.

In a later paper, appearing in July, 1913, and read before the International Congress at London, Dr. Jackson reports 193 cases of esophagoscopy for foreign bodies performed in the large clinics by presumably skillful operators. The foreign body was successfully removed 155 times and escaped into the stomach 26 times. There were 12 deaths, of which 4 were due to anesthesia by chloroform. Death occurred after the operations in 8 cases, of which 7 were esophagoscoped by operators whose total number of cases had been less than 3.

Dr. Jackson uses only local anesthesia, even with children. In his last 107 esophagoscopies and bronchoscopies in children under 6 years of age, he has succeeded with local anesthesia alone. In 206 cases of foreign body in the esophagus, in all classes of patients, he has removed the offending body 198 times. In this series, 4 deaths occurred, 1 in a woman of 56 years with advanced nephritis. In the 3 others, severe lacerations of the esophagus had been produced by other operators during previous attempts to remove the foreign body.

These figures contrast strongly with the 20.93 per cent. of mortality among 217 cases collected by Kaloyeropulos, in which the foreign body was removed by external operation. This last figure, of course, does not include the more dangerous intrathoracic route for foreign bodies imbedded in the lower esophagus. The same unfavorable mortality, due to the open method for the removal of foreign bodies, appears in the statistics of Egolff Balacescu, von Kohn, Neumann, and Levy. Von Hacker first successfully removed a foreign body from the esophagus by esophagoscopy, and from that time, up to 1907, he has successfully removed foreign bodies from all of 38 patients referred to him. In Starck's series of 78 patients, which includes the patients of Mackenzie, von Mikulicz, Rosenheim, Merkel, Ebstein, Gottstein, Killian, Killian-Eicker, von Hacker, Winternitz, Starck, Reizenstein, Harmer, and von Schrotter, there have been no failures.

In 1911, Lerche collected from the literature 200 cases. Among these, there was a mortality of 12.5 per cent., but no deaths among 47 of these cases in which the body was removed by esophagoscopy. Of the patients who died, among those who did not have the benefit of esophagoscopy, 23—or 11.5 per cent.—died of perforation of the esophagus. Besides the 23 deaths due to perforation of the esophagus, there were 18 cases of perforation of the abdominal viscera, with 2 deaths.

The following list of the foreign bodies in the series of patients collected by Lerche will illustrate the varieties most frequently impacted: tooth-plates, 41; pieces of bone, 34; coins, 26; pins and needles, 22; open safety-pins, 18; fish-bones, 4; metal whistles, 7; metal buttons, 5; pieces of wood, 4.

Foreign bodies may remain impacted within the esophagus for long periods of time before causing serious trouble. The accompanying illustration shows a nickel five-cent piece found in the esophagus of a child. The presence of the coin was entirely unsuspected, and the child died of thrombosis of the pulmonary artery. Of the series of cases collected by Lerche, the longest period of lodgment of a foreign body in the esophagus was 4½ years.

Importance of Skill in Esophagoscopic Treatment.—In spite of the excellent results of extraction of foreign bodies with the aid of the esophagoscope, considerable care is necessary in the operation, and only those who understand esophagoscopic technic should attempt the removal of foreign bodies by this means. This fact has been emphasized by Jackson; its importance and his high authority deserve quotation.

“From the number of cases of traumatic esophagitis and septic mediastinitis and pleuritis into which I have been called in consultation, I feel that the mortality at the hands of the untrained must be many times greater than is evident from the statistics.” Jackson received, as confidential correspondence from laryngologists in need of help and advice, accounts of 8 deaths from unskillful attempts at esophagoscopy by the untrained. He believes that “esophagoscopy and gastroscopy differ from almost all other departments of medicine and surgery in the manual dexterity which they require, a dexterity which is separate from a knowledge of the problem; hence, they should never be attempted without long previous training under instruction of a competent master.”

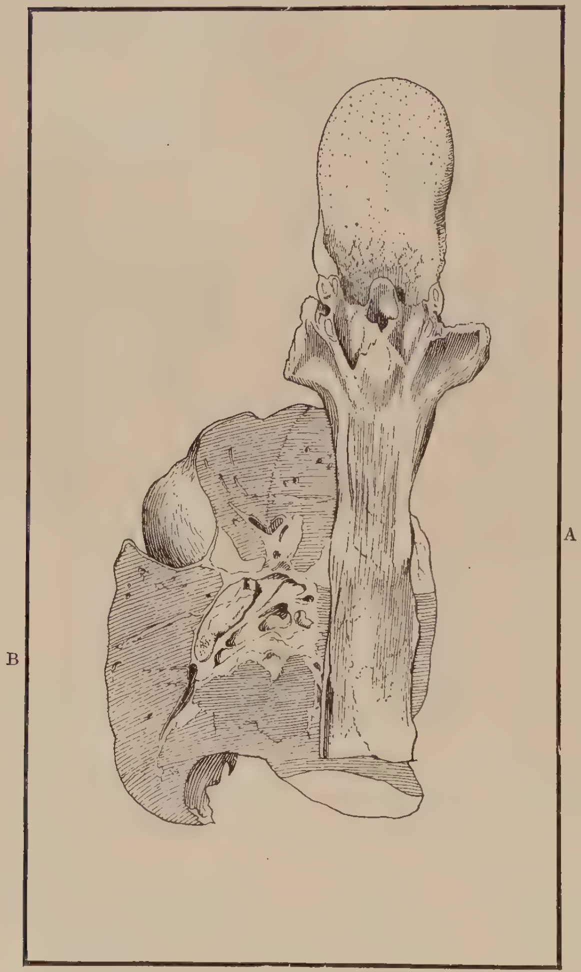


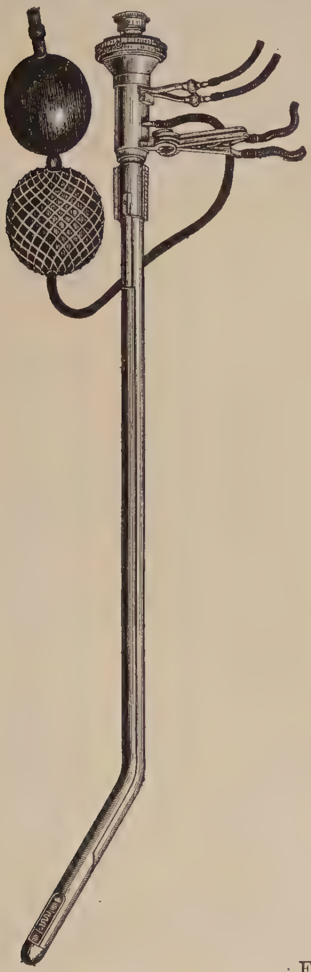
Fig. 21.—Autopsy Specimen of a Child. The cause of death was previously unknown. At the level of A a 5-cent piece was found imbedded in a perforating ulcer of the esophagus and adjacent to this ulcer a thrombus filled the pulmonary artery. The thrombus is shown at the level of B.

These facts regarding the presence of foreign bodies in the esophagus and their removal by the aid of esophagoscopy are fully sustained by other more recent articles by Schousboe, Tilly, Botella, Guisez, Voss, Körner, Reuter, Jurasz, Makkas, Blanel, Reinking, McKinney.

All these authors emphasize the danger from untreated foreign bodies in the esophagus and the uncertainty of diagnosing their presence by any other means than by the esophagoscope.

GASTROSCOPY

History and General Principles.—At the same time that von Mikulicz was experimenting with esophagoscopy, he attempted to invent a successful gastroscope. His ambitions for gastroscopy were too great. They led him to an attempt which ultimately, in his own hand, proved impracticable, namely, the bringing of the distal end of the gastroscope into easy contact with all portions of the gastric mucosa of the distended stomach. He became convinced, from experiments upon the cadaver, that a rigid tube could not be introduced into the greater curvature of the stomach of normal individuals. Subsequent experience has demonstrated that he was mistaken, and this error was responsible for the lack of development in gastroscopy during the following 25 years.



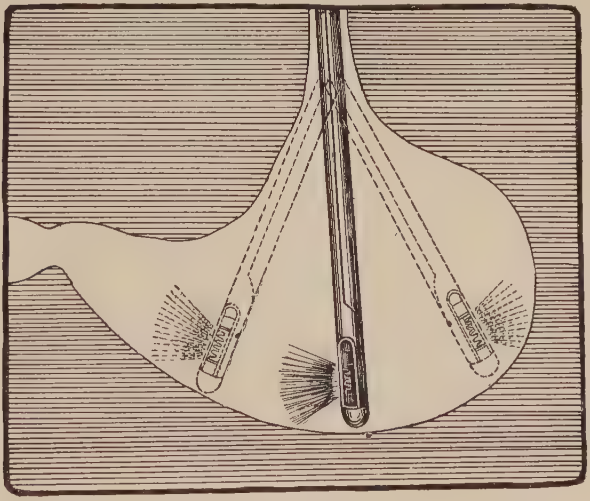


Fig. 22.—Von Mikulicz Gastroscope.

Believing that the anterior curvature of the twelfth dorsal and first and second lumbar vertebræ presented an impassable obstruction to the passage of a rigid straight tube into the stomach, von Mikulicz devised the instrument illustrated in Figure 22. The instrument is provided with distal illumination, 2 water-cooling tubes, a tube for the aspiration of the stomach contents, and a tube for the distention of the stomach with air. In addition to all these auxiliary parts, it is provided with a lens system and a deflecting prism at the angle of the bend. It measures 65 cm. by 14 mm., the angle contained between the middle and ventral thirds being 150°. The whole plan of the instrument was most ingenious, but, while diminishing one of the difficulties encountered in gastroscopy, von Mikulicz added other problems far more serious. Because of the practical bearing of these difficulties upon the successful performance of gastroscopy, they will be explained in some detail.

Von Mikulicz did not use general anesthesia, as he correctly considered it unsafe to pass a rigid instrument into the stomach without the aid of the patient's sensation. At first he used no anesthesia and it is not surprising that he found the retching and discomfort so great that he was unable to accomplish anything. With morphin anesthesia, however, he was able to allow the instrument to remain within the stomach long enough to obtain some glimpses of its interior. Inasmuch as nothing was published concerning the use of this instrument, it was probably unsuccessful. The reasons for failure are evident to anyone who has had experience in gastroscopy. The stomach is an organ far more difficult to manage than the bladder. It possesses 2 openings, neither of which controls its contents with the same degree of security with which fluid is retained by the sphincter of the bladder. It is impossible, as von Mikulicz discovered, to distend the stomach successfully with water, since distention with water almost always excites vomiting. Moreover, many of the pathological lesions in the stomach cloud a water medium.

It is impossible to completely empty the stomach of all food, and equally impossible to wash out a stomach and drain off all the water. It is surprising how much is retained after the most painstaking lavage. The surest way to secure an empty stomach is to withhold all food and drink for a sufficient length of time before the examination. Even after this precaution, some fluid will always be found within the stomach. This fluid will invariably cause clouding of any lens system which is introduced within the stomach without a preliminary preparation of the interior of the stomach to receive an optical instrument. Upon this precaution, more than upon any other, depends the successful examination of the interior of the stomach by an indirect method. The stomach cannot thus be prepared without first introducing within it a direct endoscope.

By means of the endoscope, every centimeter of the esophagus and stomach can be explored as the aboral end of the gastroscope is advanced from the beginning of the esophagus to its final destination within the interior of the stomach. Such a method of introduction permits of the detection of any abnormal conditions in the path of the end of the instrument and, therefore, it is absolutely safe. It enables the operator to obtain his bearings within the stomach and finally withdraw the residual fluid. While it is very difficult to empty the stomach completely with a stomach tube, I have experienced little difficulty in withdrawing through the esophagoscope so much of what remains in the stomach after fasting that the subsequent examination of the interior of the stomach by indirect lenses was not interfered with.

The successful use of the direct endoscope is a prerequisite to the successful use of the indirect telescope within the stomach. Moreover, the information obtained by the proper use of the endoscope within the stomach is of the greatest value in itself. A large portion of the stomach can be explored by this instrument, particularly if the stomach is dilated with air. By means of the endoscope, foreign bodies within the stomach and small bits of tissue for microscopical examination may be removed. I believe that its value is underestimated and that an exaggerated value is placed upon the indirect telescope. The satisfactory character of the views obtained by the latter is illustrated by the pictures accompanying this article.

The indirect telescope will probably prove of greater value in normal stomachs—in that it furnishes a negative diagnosis—rather than in the diagnosis of actual lesions, at least of cancers. It enables the operator to view rapidly a considerable portion of the stomach. A successful use of the indirect instrument, however, is only made possible by the preliminary preparation of the stomach by means of the straight endoscope. Without the latter, indirect gastroscopy is a failure.

We owe to Dr. Chevalier Jackson the demonstration of the fact that a rigid, straight tube can be passed into the stomach of a normal man, and made to traverse much of the interior of this organ. As a result of the conclusions of von Mikulicz that gastroscopy could not be performed by the use of a straight rigid tube, practically no attempts were made to examine the interior of the stomach directly for the following 25 years. Only 2 attempts during this period deserve mention, that of Rosenheim and that of Rewidzoff.

In 1896, Rosenheim designed an indirect optical gastroscope consisting of 3 straight, rigid tubes. The outer tube, designed to be introduced blindly, was closed with a rubber tip at the end. Within this fitted a middle tube carrying the lamp, cooling canals, and inflating tube, while the innermost tube was the telescope. The middle and outer tubes contained windows which could be rotated after introduction over the lens, so that the interior of the stomach could be viewed through them, or the prism could be completely covered by the sheath and thus protected during its introduction. The same objection applies to this instrument as to that of von Mikulicz.

A much better instrument was that designed by Rewidzoff in 1897. For the outer tube of Rosenheim, he substituted a flexible gum elastic sheath, later replaced by a rubber tube. This is first blindly passed within the stomach, and through it is passed a rigid straight periscope. Loening and Steida have published some very satisfactory views of the interior of the stomach obtained by this gastroscope. The instrument, however, obviates in no way the serious objectionable technic of necessitating a blind introduction of the outer tube and of failure to provide for preliminary preparation of the stomach before the introduction of the optical apparatus. It remained for Chevalier Jackson's demonstration of the feasibility of endoscopy, not only to prepare the way for the indirect examination of the stomach by an optical instrument, but also to reveal the very great value of the endoscope itself.

Regarding the relative values of the 2 methods, I am satisfied that the information which they impart when used together can be obtained in no other way and is more than is to be obtained by each method used separately. Undoubtedly, direct endoscopic examination, unless conducted under deep anesthesia and combined with external manipulation of the walls of the stomach, will not bring important portions of the stomach into view—portions which can be seen with the indirect view under moderate distention of the stomach.

Instruments.—If von Mikulicz may be called the father of esophagoscopy, Jackson may properly be termed the father of gastroscopy. I have modified the Jackson endoscope for gastroscopy in the same respects in which I have modified the Jackson esophagoscope. The accompanying figure (Fig. 23), coupled with the description of the esophagoscope, will make these modifications clear. The only difference between the esophagoscope and the gastroscope is that the latter is longer and its lamp is attached to a complete inside tube of extreme thinness. The gastroscope is 24 inches (60 cm.) long and 11 mm. in diameter. As has been explained, the lamp is screwed to a tongue-like separate portion of this inside tube which causes the lamp to spring into the recess of the sheath when the inner tube is in place within the outer one. I have also added the glass tube which fits by a ground cylindrical casing into the proximal end of the gastroscope. By means of this attachment, the stomach may be distended with air after the gastroscope has been inserted within it. Figure 23, C, represents the piece bearing the lamp used with the indirect periscope. The lamp is a very large one, completely filling the lumen of the outside tube. It fully illuminates the distended stomach. It is attached to the stem in such a manner that when the indirect telescope (Fig. 23, D) is introduced after it the lamp is pushed to one side and occupies the relation to the lens illustrated in Figure 23, E, a position most favorable for quickly obtaining a view of the gastric mucosa. Figure 23, F, illustrates a smaller endoscopic tube which also may be used with this same large lamp. It permits a direct view of the interior of the distended stomach at a great distance from the tube. With this instrument and its various pieces, it is possible to see a large portion of the interior of the stomach with very little movement of the instrument. This in-

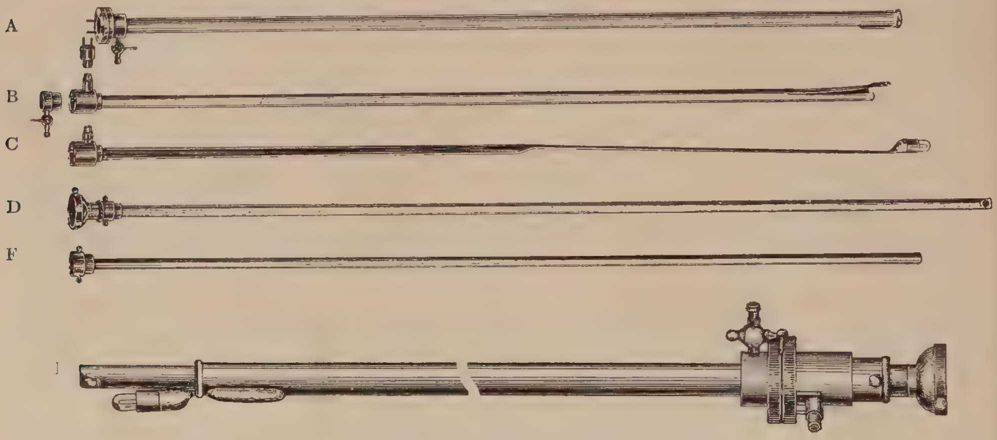


Fig. 23.—Author's Gastroscope. A, Sheath of the gastroscope; B, inner tube (endoscope) bearing the lamp; C, tube carrying the large lamp for gastroscopy; D, indirect telescope; E, relation of indirect lens and large lamp when these parts are introduced within the outer sheath of the gastroscope; F, endoscope for use with the large lamp for direct gastroscopy.

strument was developed quite independently of the knowledge of the instruments perfected by Hill and Elsner, both of whom have done much to develop indirect gastroscopy. Hill, in particular, has explained that, for successful indirect gastroscopy, preliminary endoscopy is essential.

Hill and Elsner view the interior of the stomach indirectly through a telescope inserted after the introduction of an endoscopic tube. The lamp, however, is attached at the end of the telescope and is made in one piece with it. Elsner has further published a description of an instrument with an additional prism, which can be rotated around in front of the indirect lens for the purpose of obtaining a retrograde view. The indirect instrument of Hill and Elsner has been successful. These authors have published views of the interior of the stomach and reproductions of intragastric pathological lesions. The first indirect telescope which I designed was precisely similar to the instrument of Hill and Elsner. The author has discarded the use of this type of lamp and telescope because with the lamp herein described it is possible to use a direct endoscope tube; moreover, the illumination with the lamp he is now using is better.

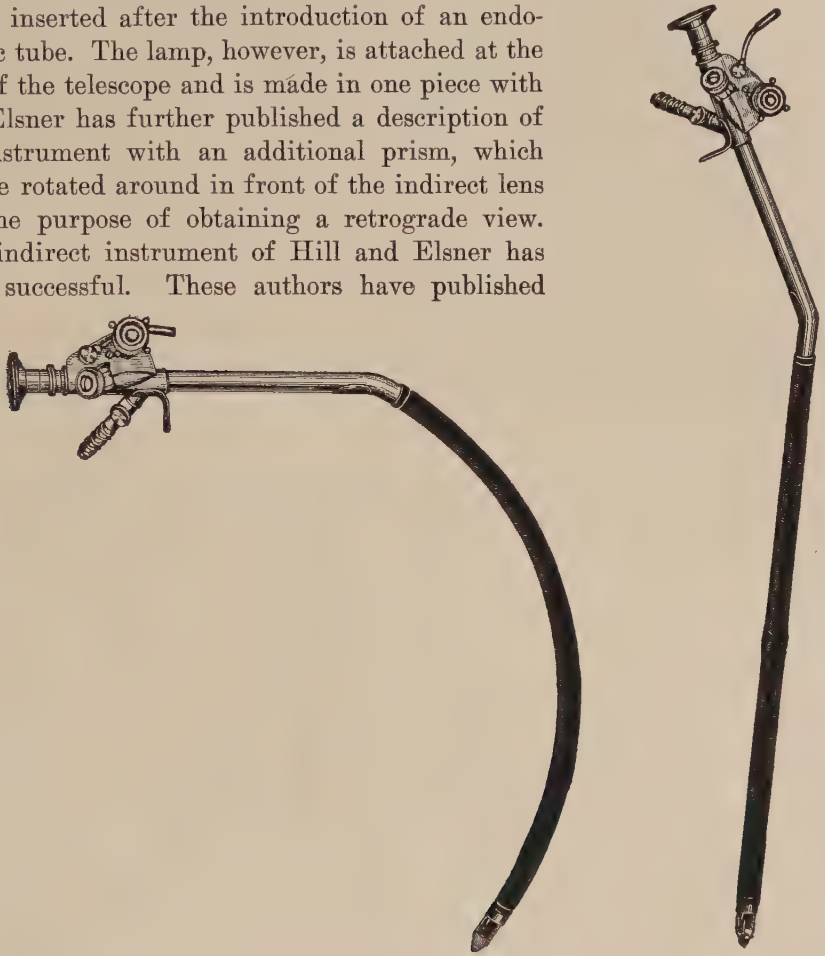


Fig. 24.—Sussmann's Gastroscope.

I have also designed an instrument by which both the direct and indirect views can be obtained after the instrument has been inserted. By pushing a prism over an indirect lens, the change is made from the indirect to the direct

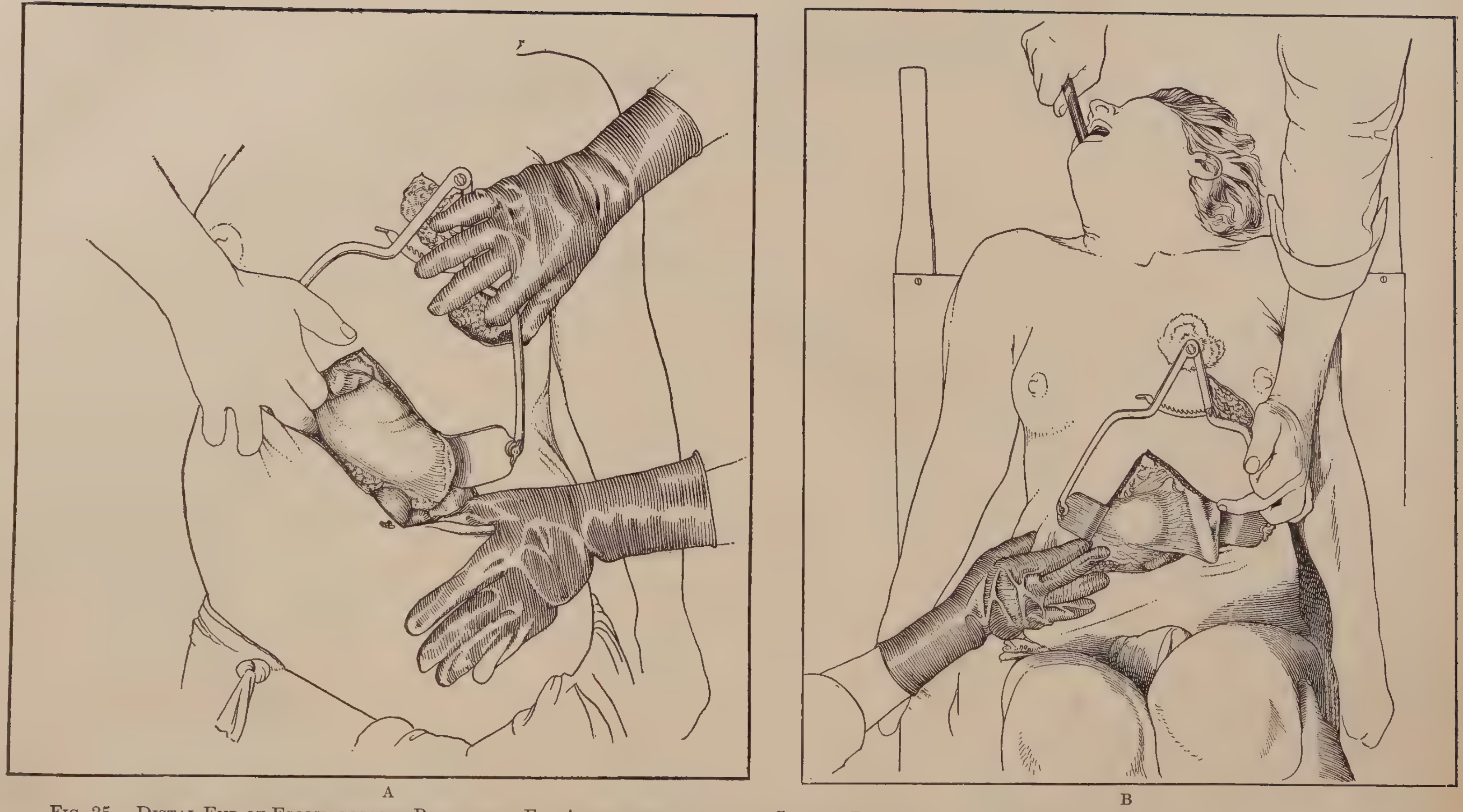
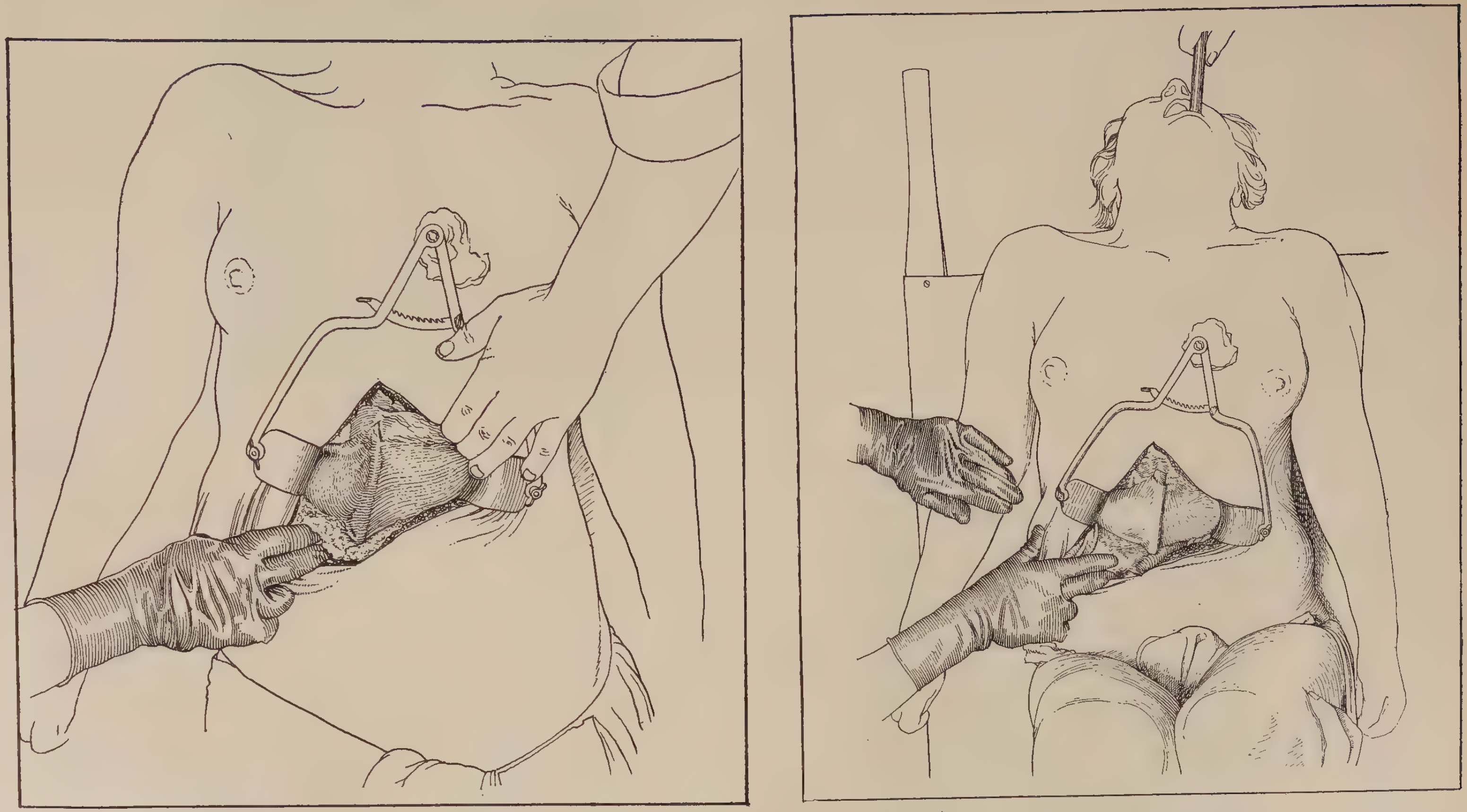


FIG. 25.—DISTAL END OF ESOPHAGOSCOPE BROUGHT AS FAR ANTERIORLY AND TO THE LEFT AS POSSIBLE. A, The knees are extended. B, The knees are flexed.



A

B

Fig. 26.—Distal End of Esophagoscope Brought as Far Anteriorly and to the Right as Possible. A, The knees are extended. (From a photograph of a cadaver with opened abdomen.) B, The knees are flexed.

view. With neither of these instruments, however, have I been able to obtain views which are as satisfactory as those given by the instrument first described, in which the lamp is very large and attached to a stem separate from the telescope. I believe that the size of the lamp and the relation which it bears to the lens of the telescope, afford advantages which are not to be secured from the instruments in which the lamp and the telescope are in one piece. Simplicity of construction is essential to success in gastroscopy. For this reason, complicated instruments, though designed to overcome certain very apparent difficulties, will not prove successful. This criticism applies to types of instruments of which the one constructed by Sussmann is an example. Though a marvel of ingenuity, it is too complicated for practical use (Fig. 24).

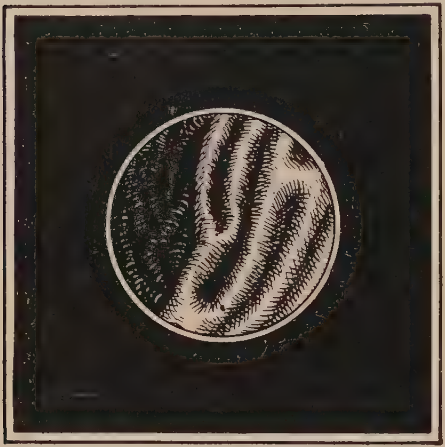


Fig. 27.—Appearance of Lesser Curvature of a Normal Stomach.

Technic of Insertion of the Gastroscope.—The technic of the insertion of the gastroscope as far as the beginning of the cardiac region of the stomach, is precisely similar to the technic of the insertion of the esophagoscope. The description, therefore, need not be repeated. The necessity for flexing the knees during gastroscopy is even greater than during esophagoscopy. Flexion of the knees not only provides for relaxation of the abdomen but also on account of flexion of the spine permits the distal extremity of the gastroscope to occupy a more anterior plane within the stomach, so that its excursions within the stomach are greater. The contrast between the anteroposterior range of movement of the gastroscope within the stomach when the thighs are extended and flexed is illustrated in Figures 25 and 26 A and B. In the majority of instances general anesthesia is desirable.

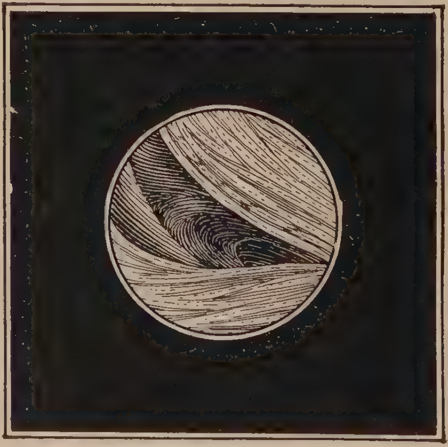


Fig. 28.—Cardiac Region of the Stomach Viewed Through Indirect Telescope.

It is quite possible to see the interior of the stomach with the aid of local anesthesia alone in many individuals without a degree of discomfort to which such patients object, nevertheless the examination is more satisfactory with the aid of general anesthesia and by it the patient is saved all discomfort. No form of anesthesia is so well suited to gastroscopy as intratracheal anesthesia by ether. I have a method of intratracheal anesthesia by nitrous oxid and oxygen which is available when objections exist to the use of ether. Ether, however, is the anesthetic of choice and the whole procedure is so short that little objection to its use exists. Its use should always be preceded by morphin.

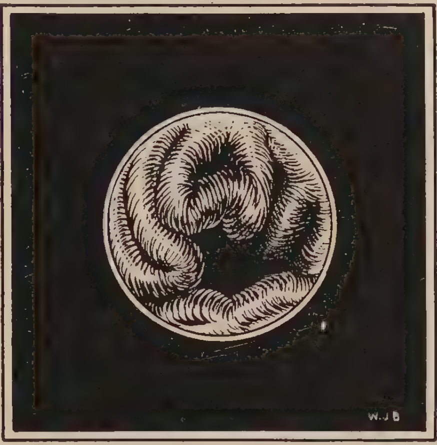


Fig. 29.—Appearance of Normal Stomach at Entrance to the Pyloric Antrum.

As soon as the aboral end of the gastroscope has passed the cardiac sphincter it is easy to recognize the different character of the gastric mucosa. The latter is a darker red and is thrown into folds which contrast well with the paler and smoother esophageal mucosa. Difficulty will often be encountered if it is now attempted to push the gastroscope further into the stomach. The end of the instrument is liable to become pocketed in one of the gastric folds, and thus its onward progress either obstructed or rendered dangerous. For the purpose of overcoming this difficulty, I have fitted the glass window over the end of the proximal extremity of the instrument. Through the inlet of the latter, which is guarded by a little stop-cock, the stomach may be distended. Its distention immediately obliterates the folds and shows the direction of the gastric canal over the lesser curvature. It is important to recognize thus the lesser curvature, as it forms the most serviceable landmark within the stomach (Fig. 27).

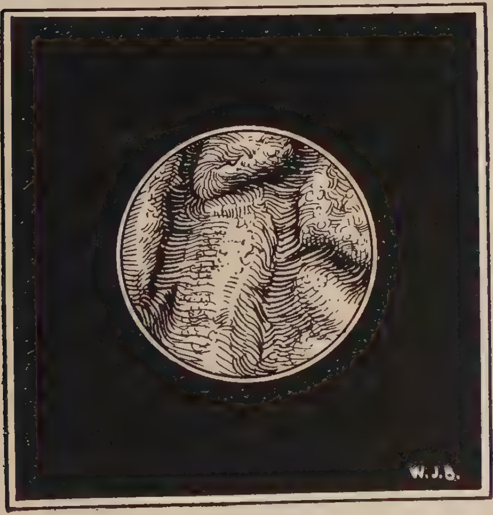


Fig. 30.—Cancer of Lesser Curvature of Stomach.

Having passed the lesser curvature, one has already inspected a considerable portion of the cardia and lesser curvature and, by advancing the instrument still further, the region of the greater curvature directly in front of the instrument will be seen. The instrument should now be withdrawn until its distal end lies in the most spacious portion of the stomach; the glass window should then be removed from the proximal end and the large lamp and indirect telescope inserted. When these are in place and adjusted in their proper relations, the stomach is again distended. In this condition, more distant views in a lateral direction toward the fundus of the stomach and in the direction of the pylorus are obtained. Moreover, the magnification by the lens renders the finest details of the mucous membrane visible. Figures 27, 28, 29 and 30 show the views obtained by the indirect method in various directions within the stomach.

If now it is desired to examine directly any portion of the greater or lesser curvature with the aid of the more brilliant illumination furnished by the large lamp, the straight endoscopic tube may be inserted in place of the telescope. It must be remembered that, when the direct endoscope is first inserted into the stomach for the purpose of preparing the stomach for the indirect method, the light is not strong enough to illuminate the interior of the distended stomach at any distance from the tube. With the combination of the large lamp and the straight endoscopic tube, however, one may see clearly the fully illuminated and distended stomach.

Value of the Direct Endoscope.—Reference has already been made to the comparative merits of the direct and indirect methods, but I desire to emphasize again the great value of the direct endoscope in examining the stomach. For the development of this instrument we owe much to Dr. Jackson. In his paper, appearing in 1908 in the *American Journal of Medical Sciences,* he refers to the following diagnoses among 70 miscellaneous endoscopies:

Chronic gastritis	6
Gastroptosis	3
Gastrectasia	2
Malignant disease of cardia	3
Malignant disease of pylorus	3
Malignant disease of lesser curvature	3
Peptic ulcer	8
Cured peptic ulcer	1
Negative results, of value	1
Foreign body removed	1
Gastric syphilis	1

With the endoscope alone, particularly if the organ is distended, it is possible to cover a large portion of the stomach, and instrumentation is possible only through an instrument of this kind. I believe that both Elsner and Hill have somewhat exaggerated the importance of the indirect method. The latter is nevertheless necessary for a complete survey of the interior of the stomach, and it greatly facilitates the rapidity of the examination. It furnishes information of a special kind which we cannot afford to be without.

Field of Usefulness of Gastroscopy.—In estimating the value of gastroscopy, 2 questions suggest themselves: (1) Is it more desirable to depend upon an exploratory laparotomy for a diagnosis of intragastric lesions than upon a gastroscopic examination? (2) Does gastroscopy furnish any more information than may be obtained by the use of the X-ray?

An exploratory laparotomy is safe. It is possible to perform it under local anesthesia, if necessary, or at least under light general anesthesia, and there are few instances when it does not reveal all that is necessary to know. As opposed to these considerations, however, it is possible to obtain—with the aid of not more, at least, than a short period of light general anesthesia—the desired information concerning the interior of the vertical portion of the stomach by gastroscopy. A gastroscopic examination will not necessitate the patient's remaining in bed until the wound is healed. A necessary subsequent operation is not delayed or embarrassed by the exploratory one. Most important of all, if concrete facts are presented to a patient, it is easier to influence him to decide intelligently upon a proper course of treatment. Moreover, if the surgeon knows the character of the lesion present and its extent, he is in a better position to know what operation should be performed than when he is obliged to decide quickly, after the abdomen is opened.

Consider a surgeon dealing with a possible new growth of the stomach, which cannot be palpated through the abdominal wall. It will be assumed that the patient has had gastric symptoms. He may have been in good health, or now and then he may have had indefinite gastric symptoms or have given a history of an old ulcer. The new symptoms of which the patient complains do not improve upon expectant treatment during a period of 2 weeks, but become worse. A radiograph is taken, which is negative. Such a case suggests cancer of the cardia. Obviously, it is wiser to attempt to see the interior of the stomach than to advise such a patient to submit to an exploratory operation. If the growth is found, and the diagnosis is confirmed by the microscope, the operator is no longer dealing with uncertainties. The patient is furnished with information upon which he can act intelligently, and the surgeon is better prepared to plan his operation. He will know, in the first place, that a malignant new growth is present and can determine its position if the tumor can be seen with the gastroscope. If the X-ray examination is negative, there is very strong evidence that the growth is small. I believe that, without the information which gastroscopy can furnish, both surgeon and patient are at a disadvantage.

Appearances of the Normal Stomach.—The appearances of the interior of the stomach are well represented in Figures 27, 28, 29 and 30, in connection with the description of the introduction of the gastroscope. Is it possible to see the pylorus? It must be remembered that the pyloric region of the stomach crosses the vertebral column. In this direction, the entrance to the pyloric region may be seen (Fig. 28). The pylorus itself I have not been able to see, though I have seen pyloric carcinomas, for the majority of the pyloric carcinomas extend into the vertical portion of the stomach. Both Hill and Elsner have said that they have seen the pylorus, and they have published pictures showing it. I have not been able to confirm their experience.

DIAGNOSIS OF PATHOLOGICAL CONDITIONS WITHIN THE STOMACH

Gastroscopy is yet so new that little opportunity has been afforded for an accurate description of the appearances of pathological lesions within the stomach. I have examined few intragastric lesions other than cancer. One or 2 illustrations of these have been reproduced. I have diagnosed 20 cases of cancer of the stomach by its appearance or by microscopical section of pieces of tissue removed at the time of the examination. Two cases of ulcer have come under my observation. In 1 the microscope showed a round-celled infiltration of the tissues; the patient left the hospital much improved. Inasmuch as both ulcer and cancer are operable lesions it is not a matter of vital importance to distinguish between them.

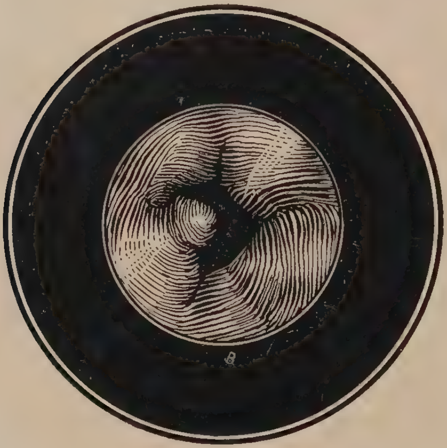


Fig. 31.—Small Outlying Nodule from a Patient with Cancer of Cardiac Extremity of the Stomach.

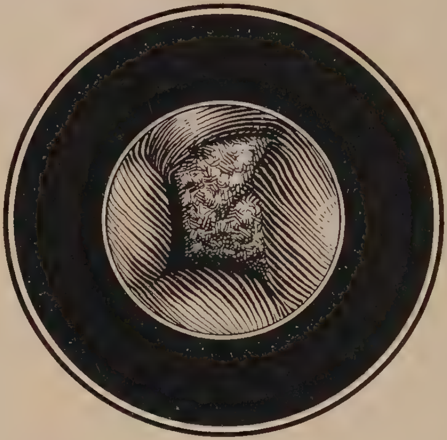


Fig. 32.—Cancer of Lesser Curvature of Stomach.

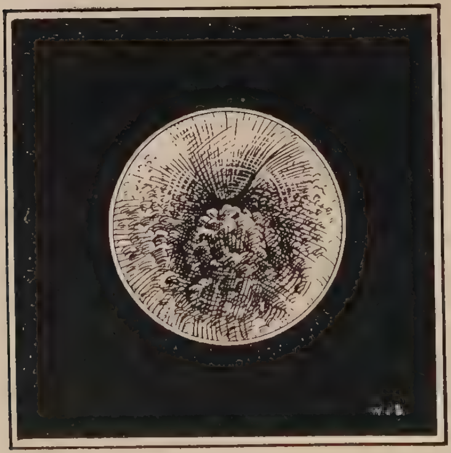


Fig. 33.—Cancer of Lesser Curvature of Stomach.

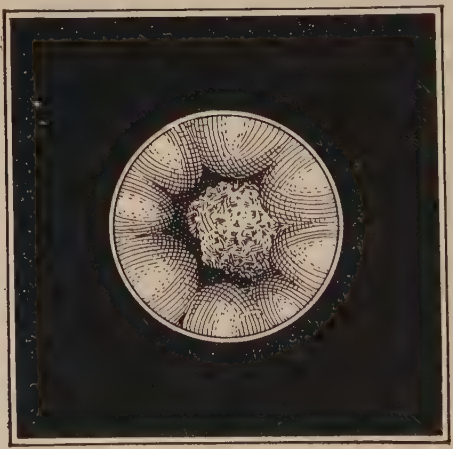


Fig. 34.—Cancer of Cardiac Region of Stomach.

Of the intragastric lesions which may be discovered by gastroscopy, ulcer and cancer are the most important. Later the changes due to the various functional gastric disturbances and chronic forms of gastritis may be sufficiently defined to enable one to recognize appearances which will be characteristic of such lesions. At present we may say that the mucous membrane of the stomach in chronic gastritis and in anemias is pale. In chronic gastritis, congested areas and mucus-covered spots are seen. In conditions associated with higher acidity, the membrane may be unusually congested, and erosions may be seen in places. In these conditions, a gastroscopic examination is of value, chiefly because it may exclude ulcer or cancer.

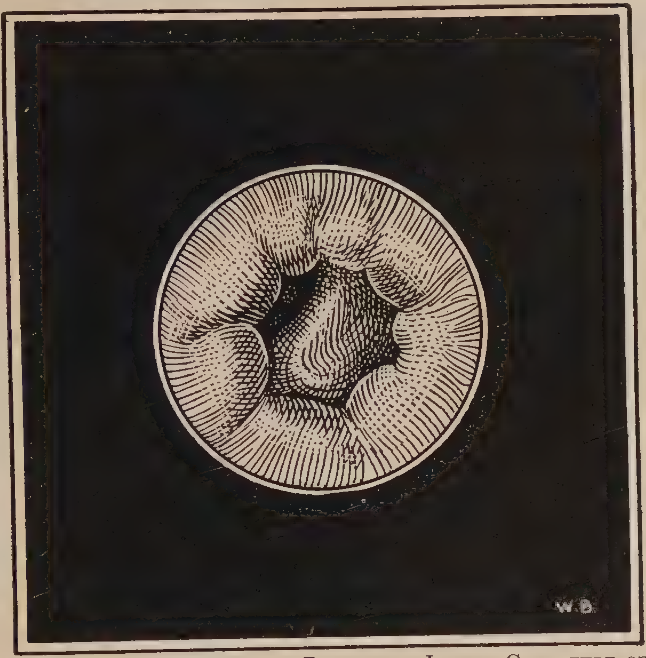


Fig. 35.—Cancer of Upper Portion of Lesser Curvature of Stomach.

Cancer and Ulcer.—Of these 2 conditions, the appearances of cancer are more typical. In cancers of the cardiac region, there is the same finely granular surface which is sometimes found in the esophagus. In other cases, there are small tumors present in the neighborhood of the primary growth. When these are found they are very characteristic and specimens for microscopical examination may be easily obtained from them. The appearance of one of these nodules is represented in Fig. 31. The edges of the main part of the growth are everted. The surface of ulcer may be covered with granulations or with slough, or the base may be granular. These tumors are best studied endoscopically. Tumors further within the cavity of the stomach differ much, according to the stage in which they are examined. Ulceration may be absent. In late stages, I have seen the pyloric and prepyloric regions surrounded by a tumor which had infiltrated the walls of the stomach beneath the mucous membrane, converting the stomach in this location into a rigid tube without ulceration. In such cases, the surface is thrown into folds resembling the normal rugæ, except that they are rigid and unyielding. It is in these cases that the indirect method of examination will be more helpful. Change in the color of the mucous membrane, abnormalities in evenness, and protrusions within the stomach will attract the attention of the surgeon to the abnormal area. A frequent appearance produced in these instances by cancer of the cardia is that represented by Figures 34 and 35. Small tumors project into the cavity of the stomach a short distance from the cardiac sphincter. Such appearances are absolutely characteristic.

After the recognition of any area which appears to be abnormal, the endoscopic tube may be inserted and a portion removed for microscopic examination. It is impossible to distinguish cancer from ulcer, at least with our present knowledge, and the microscopical examination of the tissues removed should alone be relied upon. If this shows carcinoma, we know that cancer exists; if it is negative, we cannot exclude malignancy. If cancer is present, however, and care is exercised as to the portion of the mass from which the piece for examination is taken, there should be few failures to secure tissue which is typical of the lesion. I have, however, often failed. The removal of normal mucous membrane undermined by cancer is the most frequent cause of failure to obtain a specimen of the growth itself, as such a relation of normal to diseased tissue is not infrequent in the periphery of a tumor, and it may not be possible to pass the periphery of tumors with the gastroscope.

Ulcers within the stomach have been classified by Elsner as simple erosions, as small round punched-out ulcers, or as callous ulcers. He describes these forms. I am not, from my experience, able to describe the gastroscopic appearances characteristic of ulcer, and believe that as yet the knowledge of gastroscopy has not been sufficiently broad to justify such descriptions. Most of the descriptions display a dependence upon appearances seen at autopsy or at the operating table. Such sources of information furnish better guides than actual appearances through the gastroscopic tube.

Nevertheless, this much can be alleged: carcinoma and ulcer, when seen within the stomach, can be recognized, so that when dealing with the former we are seldom in doubt as to the nature of the lesion. In the majority of cases, the diagnosis can be confirmed by obtaining a microscopical section. This latter method of diagnosis should be more or less certain, according to one's skill in selecting portions of the lesions from which to take the section.

The Gastroscope and the X-ray.—As I have stated, my own experience has been limited chiefly to cancer, and the majority of cancers which I have diagnosed have been in the cardiac region of the stomach. It is in this region that the gastroscope finds its greatest field of usefulness, though, of course, growths in this locality are far more infrequent than in the pyloric region. This fact introduces for discussion the comparative diagnostic value of the X-rays and the gastroscope.

The conclusions of such a discussion are of much importance because an X-ray examination is easily made and is accompanied by no particular discomfort. On the other hand, a gastroscopic examination is either accompanied by quite a little discomfort or necessitates a general anesthetic.

I have been fortunate enough to be associated in some of my work with Dr. Lewis G. Cole and Dr. Le Wald. Dr. Le Wald will discuss his views in another portion of this work.

To Dr. Cole unquestionably belongs the credit of having been one of the first to demonstrate that a series of bismuth shadows of the stomach may be taken at such intervals that the various stages of the peristaltic wave may be selected. He has further shown that in such a series of plates lesions of an obstructive nature within the stomach will cause changes in the various stages of the peristaltic wave which are characteristic of these lesions. Such perfection of the X-ray diagnosis of the stomach in some degree reduces the value of gastroscopy. It, however, only diminishes the value of gastroscopy in that particular portion of the stomach where gastroscopy is weakest. Dr. Cole has been kind enough to furnish the writer with an expression of his own view of the comparative values of these procedures, for publication here. He states:

"Every possible effort should be made to detect early malignant lesions of the gastro-intestinal tract. The results of the technic already described in this chapter, indicate that in the near future the esophagoscope and gastroscope will give as valuable information in the upper portion of the digestive tube as the proctoscope now furnishes at the lower end. In both these regions, the field of usefulness of these instruments is overlapped by or so closely associated with röntgenologic diagnosis that a word from a röntgenologist may not come amiss.

"TECHNIC.—The gastroscopic examination is apparently less painful than one would imagine. No one relishes a sword-swallowing feat, and few patients take kindly to the stomach tube, but it is surprising how little discomfort the gastroscope entails. The 3 or 4 patients whom I have seen examined by the method described in this chapter made less complaint than the average person makes over an ureteral catheterization, which is considered painless by the genito-urinary surgeon.

"FIELD OF OBSERVATION.—All parts of the esophagus and the rugæ on the anterior and posterior parts of the vertical portion of the stomach are revealed with a distinctness that is astonishing to one unfamiliar with the examination. The pars cardiaca, and especially the cardiac orifice, where a lesion is more likely to escape even careful röntgenologic observation, is the very region to which the gastroscope is particularly applicable.

"The information gained by gastroscopy is of two kinds:

"First: The detection of a lesion in the esophagus or vertical portion of the stomach.

"Second: Conclusions as to its malignancy or non-malignancy.

"RELATIVE USEFULNESS OF GASTROSCOPIC AND RÖNTGENOGRAPHIC EXAMINATIONS.—In their special regions, the gastroscopic and röntgenographic examinations are about equally successful in the diagnosis of such lesions, but the extent of the larger lesions, particularly on the lesser curvature of the stomach, can be determined more accurately by the röntgenographic examination. Although cardiospasm, cicatricial contraction, and carcinoma of the pars cardiaca can usually be identified röntgenographically, the differentiation between these conditions can be made with a greater degree of certainty by the gastroscope than by the röntgen examination. The röntgenogram reproduced in Figure 2 illustrates the value of this combined method of examination—in this instance, applied to the esophagus. Stereoscopic röntgenograms of this patient showed a collection of bismuth just above the root of the lungs, caused probably by pressure on the esophagus of the root of the lung on the arch of the aorta. Although the obstruction was not complete, the involvement looked suspiciously like an organic lesion, judged by a single examination. The esophagoscopic examination, on the contrary, failed to show any lesion at this point, and a subsequent autopsy demonstrated that this area of the esophagus was normal.

"The present field of gastrocolic examination does not include the pars pylorica, as has already been stated. In this region, where 80 per cent. of gastric carcinomata occur, serial röntgenography affords the most accurate information obtainable. On the röntgenographic findings alone one is justified in making a positive diagnosis of indurated gastric ulcer or carcinoma, although it is not always possible to differentiate between these conditions. However, as indurated ulcer may become malignant at any time, ulcerative processes should be considered malignant until proven otherwise by the microscopic examination of a specimen.

"VALUE OF COMBINED GASTROSCOPY AND SERIAL RÖNTGENOGRAPHY.—While each of these specialties, still new, has its own field of utility, a coöperative use of both examinations will result in a more accurate diagnosis of gastro-esophageal lesions than has ever been attained by any other method or methods, and will render infrequent, if not impossible, the failure to recognize malignant lesions in their earliest stages."

In my opinion, there can be no question that it is most desirable in every case of intragastric lesion to have the findings of both an X-ray and a gastroscopic examination. In the cardiac region of the stomach, an X-ray examination is often inconclusive. It is, however, in just this region that gastroscopy is strongest. At the present time, it would be unwise to define either how much of the stomach should be claimed by either of these methods of examination or the degree of certainty with which negative findings may be trusted throughout such fields. I believe, however, that subsequent experience will substantiate the following statements:

If the interior of the stomach appears normal through the gastroscope, the conclusion is justified that the vertical portion of the stomach is normal. This conclusion, however, is not warranted by a negative X-ray examination.

On the other hand, a negative gastroscopic examination, at the present time, does not exclude a lesion in the pyloric portion of the stomach, whereas a series of bismuth pictures taken with a frequency which shows the progression of the peristaltic wave will show a lesion of the pyloric portion of the stomach, if such exists.

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CHAPTER XI

THORACIC SURGERY

Franz Torek

SURGERY OF THE ESOPHAGUS

A. THE INTRODUCTION OF SOUNDS

The introduction of bougies into the esophagus is indicated for purposes of diagnosis and for the dilatation of strictures.

Anatomical Points.—The following anatomical points are to be noted. In the neck the esophagus lies in front of the spinal column and behind the trachea, a little to its left side, so that it projects slightly beyond the left border of the trachea. In the thorax it occupies a portion of the posterior mediastinum and is there situated still further to the left. Rarely the thoracic duct touches its posterior surface in the upper part of the thorax. At the bifurcation of the trachea, the esophagus lies behind the trachea and also behind the transverse portion of the arch of the aorta from which the trachea separates it. Below this point, it lies at first to the right of the descending aorta, and, as it crosses the left bronchus, its relative position is such that it now lies between the left bronchus and the aorta, the latter being posterior and to the left of the esophagus. Then the esophagus crosses over in front of the aorta to take its position to the left of that vessel in the lower part of the thorax. It may, therefore, be said to turn spirally around the aorta. Its shape, however, is not twisted as much as the description of its course relative to the aorta might lead one to think; for the greater part of the twisting is done by the aorta, whereas the esophagus is comparatively straight. There are individual differences in its shape; in some subjects the curve is marked, in others merely indicated. At the esophageal opening in the diaphragm, it lies markedly to the left of the median line. The last centimeter or 2 (about ½ in.) of the esophagus, rarely more, is in the abdominal cavity, where it joins the stomach.

It receives its blood supply in the neck from branches of the inferior thyroid arteries; in the chest, from branches of the bronchial arteries and of the aorta itself; in the abdomen, from branches of the left gastric artery.

It has a mucous, submucous, and muscular coat. It is covered by a layer of connective tissue which is directly continuous with the mediastinal connective tissue.

It is of importance to know that a narrowing of the lumen of the esophagus is normally present at 3 more or less well-defined places. The first of these is at the beginning of the esophagus, behind the cricoid cartilage; the second or middle constriction corresponds to the bifurcation of the trachea, though there may also exist an intermediate one between these 2 at the junction of the cervical and thoracic portions of the esophagus; the third constriction is at the hiatus œsophageus of the diaphragm or from 1 to 2 cm. (½ in. or so) above it.

One should know not only the total length of the esophagus but also the distance from the incisor teeth to certain points serving as landmarks. Three points should be known; they are, first, the beginning of the esophagus; second, the site corresponding to the bifurcation of the trachea; third, the cardiac end of the esophagus. The distances of these points from the teeth are not the same in all individuals but may vary to a considerable degree, and they are, as a rule, shorter in females than in males.

According to v. Hacker, the most frequent measurements are as follows: For males, from the teeth to the beginning of the esophagus, 15 cm. (6 in.); to the bifurcation, 26 cm. (10½ in.); to the cardia, 40 to 41 cm. (16 to 16½ in.). For females these figures are, respectively, 14, 24, and 38 to 39 cm. (5½, 9½, and 15 to 15½ in.). For facility in memorizing we may say that the first stretch, teeth to beginning of esophagus, and the last stretch, from bifurcation to cardia, measure each about 15 cm. (6 in.), while the middle stretch, beginning of esophagus to bifurcation, measures about 10 cm. (4 in.).

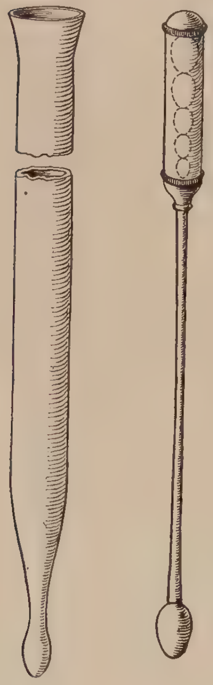


Fig. 1.—A, Conical Bougie. B, Olive-tipped Bougie.

Types of Bougies.—Esophageal bougies are of 2 kinds, the silk web bougies with conical points (Fig. 1, A) and the olive-tipped bougies (Fig. 1, B). The former are used for dilating strictures, the latter are preferable for determining the exact location of the stricture, as the olive point is arrested at the site of the constriction. If an olive point can be made to pass beyond the stricture, one can sometimes, on withdrawing it, also locate the lower end of the stricture by the resistance which the bougie encounters. Both the conical and the olive-tipped bougies are made in different sizes.

Diagnosis by Bougies.—For purposes of diagnosis, a fairly large-sized olive tip is first introduced, in order that its passage beyond the stricture may surely be prevented and the location of the stricture may be determined. Then, to determine the caliber of the stricture, smaller and smaller olive tips are inserted, until one of them passes. The stricture may be so narrow that even the smallest instrument fails to pass beyond it.

Dilatation of Strictures.—For dilating strictures, the conical silk web bougies are used. Having determined the caliber as stated above, we begin with the bougie corresponding to that caliber and gradually insert larger and larger bougies, provided that the stricture proves to be dilatable.

The surgeon sits in front of the patient, a basin at hand to catch the saliva, and the patient's clothes protected by a sheet or by towels. Artificial teeth are removed. The bougie is dipped in water, that it may glide more easily, and, in the case of the silk web bougie, for the purpose of rendering it more pliable. Of lubricating agents employed, water is the one that is least objectionable to the patient; however, oil, vaselin, glycerin, or white of egg may be substituted. The patient's head is brought slightly forward, as this position opens the introitus of the esophagus, and the bougie is introduced into the pharynx in the midline or slightly to the left of it, as the esophagus lies somewhat more on the left than on the right side. One should seek to avoid contact with the buccal cavity as much as possible in order to avoid gagging. In some cases, however, in order to facilitate the introduction of the instrument, it may be necessary to press the tongue gently forward with the left index finger. More or less resistance may be encountered at the sites where a narrowing of the lumen is normally present (compare anatomical points mentioned above). The most constant of these obstacles is at the beginning of the esophagus, behind the cricoid cartilage. This can best be overcome by causing the patient to swallow, as the bougie passes that point, on its withdrawal as well as on its introduction. To diminish the gagging, the saliva should be allowed to flow out of the mouth, the patient's face being turned slightly downward. Most patients, unless instructed otherwise, turn the face up, and in consequence the saliva flows toward the larynx and causes coughing. The tendency to gagging may also be diminished by encouraging the patient to breathe deeply. Undue force should never be employed; the bougie must be passed gently. One should feel his way, as it were, as if the tip of the bougie were the tip of the finger.

After the patient has become somewhat accustomed to the procedure of passing the bougie, the instrument can be left in place for 5 minutes or even ½ hour. To prevent the patient from biting off the bougie, a cork or wooden wedge may be introduced between the teeth. Many patients soon learn to introduce the bougies themselves.

For very narrow strictures, the silk web bougies cannot be used; filiform bougies must be employed. Those made of catgut, if not varnished, will swell when in situ and thus aid in dilating the stricture. They may be left in place for 10 to 30 minutes. In instances where difficulty is encountered in finding the entrance to the stricture, a number of filiforms may be introduced through a hollow bougie down to the stricture, and one after another may be pushed forward in a manner similar to that employed in tight strictures of the urethra (Fig. 2). Where these methods fail, attempts should be made to pass a filiform with the aid of the esophagoscope. Where a gastrostomy has already been performed, it is often possible to pass a bougie from below upward, when attempts to pass it from above downward have failed.

If a stricture has been somewhat dilated by one of the above methods, rapid progress may often be achieved by the introduction of a rubber drainage tube stretched over a long probe (v. Hacker's method). As probe or drainage tube carrier, a stiff filiform is used. As the rubber tube is stretched over the carrier, its open end will project to one side (Fig. 3, A). To facilitate its introduction into the stricture, the projecting open end is cut off (Fig. 3, B and C).

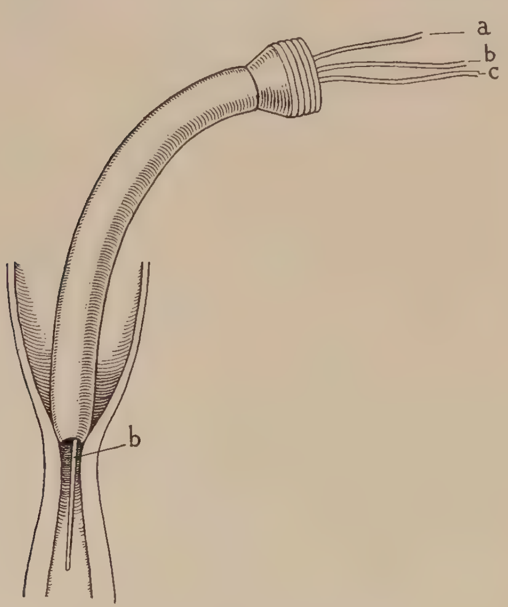


Fig. 2.—Introduction of Filiform Bougies (a, b, c) Through a Tubular Bougie Into the Stricture. b′, the Filiform, has Entered the Stricture.

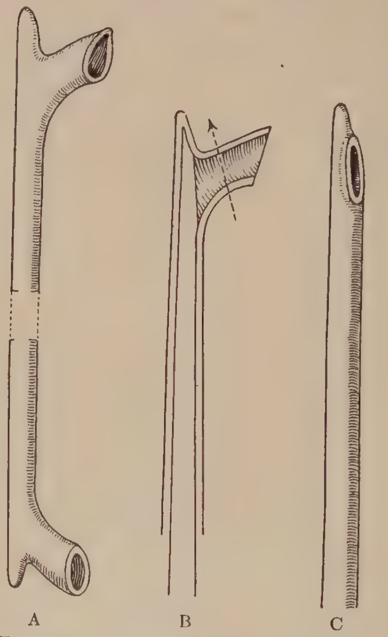


Fig. 3.—A—Stretching a Rubber Tube Over a Carrier. B and C—Cutting off Projecting End.

When the armed tube has been carried through the stricture, the outside end of the carrier is released by stretching the tube and letting it slowly glide over the carrier. The rubber tube then, by virtue of its elasticity, tends to resume the caliber it had before it was stretched and thus dilates the stricture.

No matter what method is employed, the dilatation must be gradual and gentle. If pain or fever occurs during the course of treatment, the introduction of bougies must be intermitted to avoid the formation of ulcer with possible periesophageal phlegmon or perforation.

A very ingenious method of aiding the esophageal bougie to find its way down is one using a thread as a guide, as recommended by Mixter and Plummer. Olive-tip bougies are used, the olives of which are provided with drill holes from the tip to 1 side of the base for threading (Fig. 4, A). The patient slowly swallows 6 yards of buttonhole silk. The first portion of this forms a snarl in the esophagus or stomach. Plummer, therefore, recommends letting the patient swallow 3 yards during an afternoon and the remaining 3 yards on the following day. The first portion passes into the intestine during the night, and the remainder usually follows without snarling. This thread of silk passes down the intestines sufficiently far to prevent its withdrawal on being pulled taut. The silk is now threaded into the olive, and the bougie is passed under its guidance. The passage of an unguided instrument is particularly difficult in cases of diverticulum and cases of dilatation proximal to a constriction, whether organic or spasmodic, the tendency always being for the instrument to become pocketed in the diverticulum or in the pouch-like dilatation. The threaded olive will likewise enter the diverticulum as long as the thread is left loose (Fig. 4, B); but when it is drawn taut, the olive is raised out of the pouch, and it can then be passed into the proper channel (Fig. 4, C). Similar conditions will obtain when there is a bag-like dilatation above a constriction. With the aid of the threaded bougie, it is also possible to determine the site and depth of a diverticulum. The bougie is passed to the bottom of the pouch, the thread being slackened slightly; then a pull on the silk raises the bougie to the place where the esophagus continues downward.

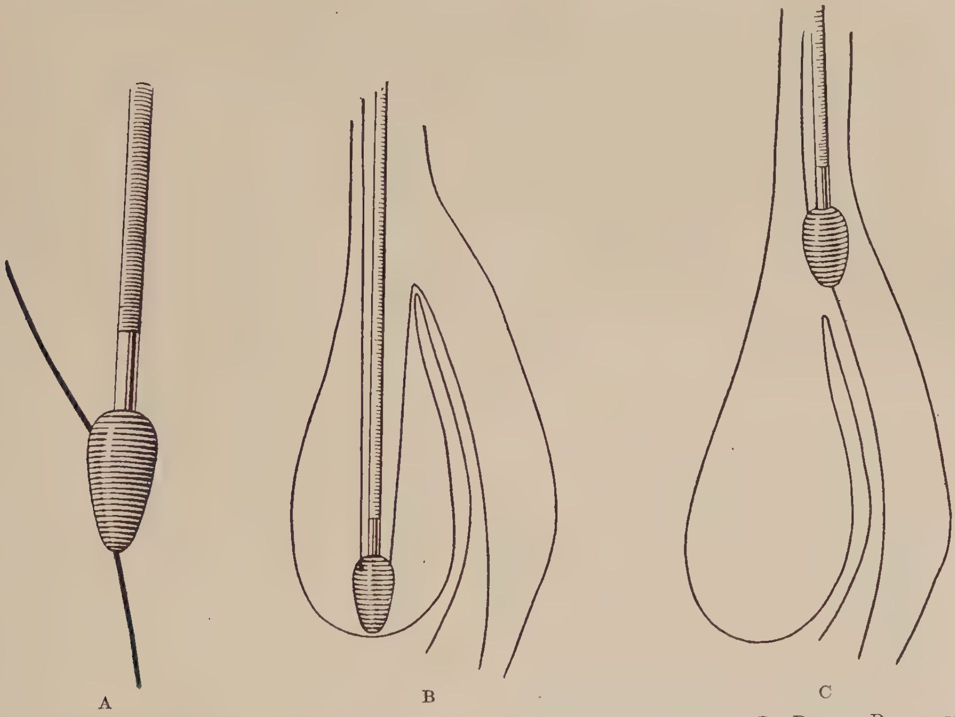


Fig. 4.—A—Olive Tip Bougie with Guide Silk Threaded Through Olive; B—Bougie Pocketed in Diverticulum; C—Traction on Guide Thread Raising Bougie out of Pocket and Directing it Into Proper Channel.

Electrolysis has been used with good results. The negative pole is brought in contact with the structure, while the positive pole, attached to a broad, flat electrode, is placed on the thorax. A current of 15 milliampères is applied for 50 to 60 seconds.

Where dilatation by any of the above methods is impossible, operative measures are employed. These are internal or external esophagotomy, gastrostomy, and combined operations.

Dangers.—A disregard of the rule that the passage of bougies must always be gentle, or, still worse, the use of brute force in the presence of an obstacle, is apt to cause perforation just above a stricture or at the site of an ulcer or carcinoma. If an aneurysm of the aorta exists, there is great danger of perforating it and causing immediate death. This accident has occurred repeatedly. Another danger is that of introducing the bougie into the larynx and causing suffocation. Ordinarily the irritation would promptly cause a violent spasm of coughing and thus give warning of the mistake, but in the presence of anesthesia the error might not be noticed promptly.

Contra-indications.—If we know that aneurysm of the aorta is present, the passage of a sound should be avoided, if possible. However, the presence of an aneurysm as the cause of esophageal obstruction may be unknown when the bougie is introduced for purposes of diagnosis or treatment. I described, in 1891, 2 cases with marked obstruction in which I had introduced bougies for the purpose of dilating what was supposed to be a malignant stricture of the esophagus. In the course of this procedure I observed that, when the bougie was in situ, its stem could be seen and felt to pulsate. This symptom led me to suspect the presence of aneurysm of the aorta, a diagnosis which was later substantiated by additional clinical symptoms. The cases demonstrated a new symptom of aortic aneurysm in the pulsating esophageal sound. Of course, this pulsation will take place only if the aneurysm impinges on the esophagus, and it is, therefore, most likely to be found in cases where the aneurysm causes esophageal stenosis. If, therefore, the bougie transmits pulsations, one should be very wary of reintroducing it.

Although opposed to former views, we must consider the presence of carcinoma of the esophagus to be another contra-indication to the passage of sounds. Irritation of a carcinoma is apt to cause it to grow more rapidly, in this location, as elsewhere. One should, therefore, desist from passing sounds oftener than necessary for a diagnosis. Formerly, dilatation was a recognized method of treatment of carcinoma of the esophagus; in the light of our present knowledge, this practice must be condemned, especially since I have demonstrated and proved the possibility of successful surgical removal of esophageal carcinoma (page 510).

In non-dilatable strictures the passage of bougies should not be persisted in; they are cases for operative treatment. In congenital stenosis of the esophagus, if the bougie fails to pass when handled gently, one should desist. These cases sometimes have complete atresia of the esophagus.

I saw a case of this nature in consultation, in a baby 4 days old, that had vomited everything since birth. Bougies would not enter the stomach. I counseled the performance of gastrostomy and warned against further attempts at passing bougies. The family physician, however, permitted himself to be urged by the parents to make another attempt to pass a sound. This time he succeeded in overcoming the obstruction, and the baby swallowed some milk which did not return. Death occurred soon after, and autopsy revealed that a complete atresia of the esophagus had been present, and that the bougie had perforated through the bottom of the blind pouch into the pleura.

B. ESOPHAGOTOMY

1. Internal Esophagotomy

Internal esophagotomy with the aid of an instrument similar to Maisonneuve's urethrotome is a dangerous procedure, as it may be attended by perforation of the esophagus or injury to neighboring organs occasioned by entrance of the instrument into a false passage; or it may be followed by peri-esophageal phlegmon. It has, therefore, been abandoned. Under the guidance of the eye, with the aid of the esophagoscope, internal esophagotomy stands upon a sounder footing. (See Vol. III, Chap. X.)

2. Internal Esophagotomy Combined with Gastrostomy

An interesting and very successful method is that of Dunham, who employs silk threads and guides. Dunham has perfected Abbe's method of sawing into a stricture with a silk thread by wedging an olivary dilator into or against the stricture, thus pressing the string against the wall of the stricture which it is intended to cut. The method presupposes the presence of a previously made gastrostomy opening. The procedure is as follows:

The patient swallows a silk thread which is passed through an ordinary glass drinking tube, and the loose end of which is allowed to float in a glass of water. As the water is sucked through the tube, the silk thread is washed down the esophagus. Its lower end is then caught through the gastrostomy wound. Now a long, stout, linen fishing line is taken, and the upper end of the swallowed thread is tied to it at its middle. The strong thread is pulled through till its doubled end has emerged from the gastrostomy opening. The doubled end is cut, so that we now have 2 strings in the esophagus. One of these is to serve as a saw, the other for the purpose of introducing metal spindles of different sizes into the esophagus. The spindle is locked at each end to a wire which serves to guide it to the proper place (Fig. 5, A), the wire in turn being introduced by one of the linen threads to which it is tied. A small spindle is first used. While an assistant draws it snugly against the stricture, the surgeon makes sawing motions with the fishing line, cutting into the stricture against which the thread is pressed by the spindle. This sawing is continued until the spindle passes the stricture. Then successively larger spindles are locked to the wires, and the process of sawing is repeated. To guard the soft parts of the pharynx and stomach from injury by the fishing line and the wire, 2 guard tubes are used, 1 for the pharynx (Fig. 5, B), and 1 to be introduced through the gastric fistula to the cardiac orifice (Fig. 5, C). Not too much should be attempted at 1 sitting. In the interval between operations the patient retains a thread in the esophagus, the upper end of which is fastened to the face, the lower to the abdomen. At the next sitting this thread serves to introduce a new doubled fishing line, and the operation is repeated as before. When the largest spindles pass through, the patency of the esophagus is preserved by the passage of sounds. Instead of wires and spindles, a filiform guide bougie on which is locked an olive-tipped dilator may be used.

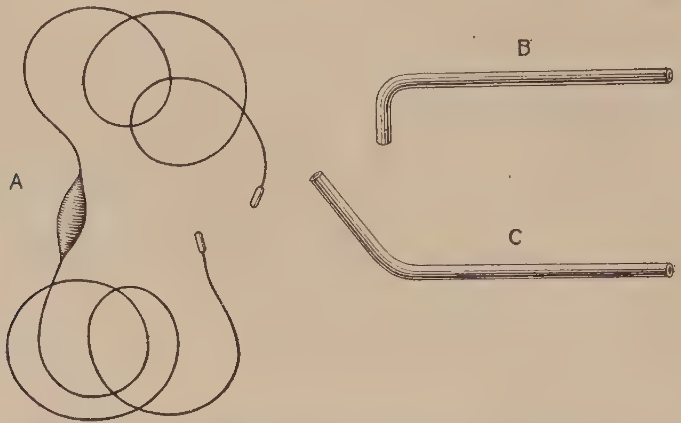


Fig. 5.—A—Dunham's Wire-and-Spindle Bougie; B—Guard Tube for Pharynx; C—Guard Tube for Stomach.

3. External Esophagotomy

Indications.—This operation is performed for the removal of foreign bodies that cannot be extracted by bloodless methods (see chapter on Esophagoscopy), also for the cure of certain strictures favorably located for this method of treatment and not capable of being treated by dilatation. In regard to the former indication, the following rules will serve as a guide: 1. Foreign bodies recently swallowed should be removed by external esophagotomy within 24 hours after bloodless methods have failed. 2. Foreign bodies swallowed some days previous require immediate operation, if bloodless methods fail. 3. If the nature of the foreign body is such that its movement up or down would involve danger, immediate operation is indicated. 4. Immediate operation is also indicated if there is hemorrhage from the mouth. 5. The most absolute indication for immediate operation is the presence of peri-esophageal phlegmon and mediastinitis.

In cases of stricture, external esophagotomy is employed: 1. To incise strictures situated in the neck. The incision is made in the longitudinal direction, whereas the healing occurs more in a transverse direction, thus tending to widen the lumen. 2. To establish an esophageal fistula for the introduction of food, if the obstruction is higher up. 3. Sometimes for the purpose of dilating strictures situated below the upper thoracic aperture. 4. For the purpose of incising strictures situated below the upper thoracic aperture, through the esophagotomy opening — the so-called combined esophagotomy (Gussenbauer), a combination of external and internal esophagotomy.

Anatomical Points.—In the neck the esophagus deviates slightly to the left, projecting somewhat farther out than the left border of the trachea, which lies in front of it. The recurrent laryngeal nerve runs upward in the gutter between the esophagus and the trachea. The structures in front of the lateral border of the esophagus are the skin and superficial fascia, the platysma, the sternocleidomastoid, sternohyoid, and omohyoid muscles, the thyroid gland, and the middle layer of the deep cervical fascia, which is continuous with the capsule of the thyroid gland mesially and with the sheath of the great vessels laterally.

Technic.—As the esophagus projects somewhat beyond the trachea on the left side, the operation is usually performed on that side of the neck. It may, however, be performed on either side. The claim that the danger of injury to the recurrent nerve is greater on the right side has been exaggerated; the danger certainly exists also on the left side. If esophagotomy is done for the removal of a foreign body, the seat of that body or of the accompanying inflammatory process determines on which side the operation is to be performed. Incision is made along the anterior border of the sternocleidomastoid muscle from the hyoid bone to the clavicle. After the skin, the platysma, and the superficial fascia of the neck have been divided, the sternocleidomastoid muscle is retracted laterally and the sternohyoid mesially. The omohyoid muscle is divided. The middle layer of the deep cervical fascia, which also envelops the thyroid gland and is attached to the sheath of the great vessels, is now exposed to view. Access to the esophagus is obtained only after this fascia has been divided, which is done by an incision made mesially to the carotid sheath. Now the thyroid gland and larynx and trachea can be well retracted to 1 side, together with the sternothyroid and sternohyoid muscles, and the great vessels are drawn to the other side, together with the sternocleidomastoid muscle. The inferior thyroid artery is seen coursing across the field, passing from beneath the common carotid mesially toward the thyroid gland. The longus colli muscle lies in the background. The inferior thyroid artery is divided between 2 ligatures. Underneath it the esophagus presents. Care must be taken to avoid injuring the recurrent laryngeal nerve, which lies in the groove between the esophagus and the trachea. If necessary, it should be retracted mesially with a small hook. The esophagus is opened on its posterolateral aspect in order to avoid injury to the nerve. A bougie is introduced to facilitate the incision of the esophagus.

If the operation is made for the removal of a foreign body, this is grasped and released by careful levering motions, avoiding all undue force. A stomach tube is now introduced through the esophagotomy wound for the purpose of feeding, a cigarette drain is carried to the esophagus below the tube and another one toward the mediastinum, and the rest of the wound is closed in 2 layers. If any peri-esophageal inflammation is present, the entire wound is left open, and the dressings are changed every few hours. The tube is removed in about 7 days. The first few days after the removal of the tube the wound should be held closed during deglutition by pressing a pledget of gauze or cotton on it.

In simple cases, where the wall of the esophagus is uninjured, the esophagotomy wound may be closed by a double row of catgut sutures. Favorable conditions for suture will not usually be found: for it is the prognostically serious cases that are treated by operation, esophagoscopy being employed in the less serious ones. But even if the esophagus wound is closed, the external wound must be drained in every case, also toward the mediastinum. In cases favorable for suture, Hans recommends median incision of the esophagus after cutting the skin in the median line. He considers this easier and believes that the closure of the suture is rendered safer by the trachea lying over it.

If peri-esophageal phlegmon and mediastinitis are present, the incision is made on the side of the supposed seat of the perforation at the anterior border of the sternocleidomastoid muscle and is deepened down to the esophagus. The esophagus is followed downward in the course of the pus to the depth of the mediastinum. If there is pus on both sides, a bilateral incision is made. The esophagus is opened at the site of the perforation, the foreign body removed, and a stomach tube introduced. Extensive drainage is made, both upward in the neck and downward into the mediastinum. The wound is left open in its entire extent. The foot end of the bed is raised to facilitate the drainage of the mediastinum, and this position is retained until the secretion of pus has diminished and the septic process has become localized. A preliminary gastrostomy may be performed to simplify the wound treatment.

DANGERS OF ESOPHAGOTOMY

Aspiration pneumonia may arise as a sequence either of the narcosis or of the manipulation of the throat and consequent swelling. Phlegmon and mediastinitis may develop subsequent to operation. Metastatic abscesses may ensue. Septic erosion of the blood-vessels may result, which, as a rule, is fatal. The treatment consists in digital compression, until the vessel can be isolated and tied. This is very difficult of accomplishment. Another sequence of a less serious nature that may occur is the persistence of esophageal and mediastinal fistulæ. The former usually close even after the lapse of months, and if they fail to do so, they may be closed by operation.

C. OPERATION FOR DIVERTICULUM OF THE ESOPHAGUS

Anatomical Points.—Compare anatomical points under Introduction of Sounds and External Esophagotomy. Although diverticula may occur in any part of the esophagus, they are found, as a rule, in the uppermost part of that organ, their existence in other parts being extremely rare. They consist of pouches of greater or less size, the neck of which is about the level of the cricoid cartilage. The pouch descends behind the esophagus and more frequently to the left side. Its wall regularly consists only of a protrusion of the mucosa, the muscular coat of the esophagus being lacking. The diverticulum may, therefore, be considered to be a hernia of the mucosa. As it dilates, it presses more and more upon the esophagus, narrowing its lumen, so that, when an esophageal bougie is passed, it regularly becomes pocketed in the diverticulum (see page 495). Viewed through the esophagoscope, the continuation of the esophagus appears as a narrow slit in the wall of the diverticulum. When the diverticulum is large and filled, it may often be seen protruding at the neck, as a rule on the left side. In the fluoroscopic picture, after the patient has swallowed a bismuth mixture, the shadow of the diverticulum may be seen (Fig. 6, plate facing page 550); small diverticula, globular in shape, are seen to move up on deglutition; large ones have more the shape of a bag.

Technic.—As a preparatory measure, the teeth and mouth should be put into good condition by the removal of tartar and the use of mouth-washes and gargles. If the patient is much underfed, it is advisable to perform a preliminary gastrostomy and to postpone operation until the patient is better nourished. The situation of the sac, as seen in the radiograph, determines whether the operation is to be performed on the right or the left side. The access to the esophagus and its diverticulum is the same as that described under External Esophagotomy. If a goiter is present and interferes with the operation, it may be resected. The sac is then exposed, grasped with a blunt forceps, and thoroughly freed up to its neck by blunt dissection. If the identification of the sac is difficult, the introduction of a bougie will aid in its recognition. The neck of the sac is ligated with catgut, the sac is cut off, and the mucosa of the stump is cauterized. If the neck of the sac is large, a suture is employed instead of a ligature. The stump is buried by suturing the muscular coat over it. A cigarette drain is inserted and brought out through the lower part of the wound. In case of very large sacs reaching well down into the mediastinum, it may be preferable to do the operation in 2 stages, at first merely to deliver the sac, leaving it outside the neck, to be removed later, after the access to the mediastinum has been blocked by granulations.

If the diverticulum lies in the neck, the operation can be performed under local anesthesia with novocain, ½ per cent., and suprarenin. The deep injections, 10 to 15 c. c. or more, can be made from the posterior border of the sternocleidomastoid muscle, whereas the region of the trachea, the sternothyroid and sternohyoid muscles, the platysma, and the subcutaneous connective tissue are injected from points at the anterior border of the sternocleidomastoid muscle. The anemia produced by the suprarenin facilitates the operation.

After-treatment.—In the after-treatment attention to the mouth and teeth is again important. Alimentation is partly rectal, partly through a small-sized, soft rubber stomach tube or catheter introduced into the esophagus. Toward the end of the first week the patient may swallow fluids, and in the course of the second week his nutrition may be increased. The drain is loosened on the third day and removed on the fifth day, when it is replaced by a very small one. About the end of the second week a bougie is carefully introduced.

D. RESECTION OF THE ESOPHAGUS

1. Resection of the Cervical Portion of the Esophagus

This operation is indicated in carcinoma of the cervical portion of the esophagus. It has also been done in cases of stricture, but is not to be recommended in those cases.

Anatomical Points.—Besides the anatomical points mentioned under Introduction of Sounds and External Esophagotomy, attention is called to the fact that the deep cervical lymphatic nodes should be examined for carcinomatous involvement. There are two sets of nodes, the superior, along the upper part of the internal jugular vein, in the neighborhood of the bifurcation of the common carotid artery, and the inferior, situated along the lower part of the internal jugular vein and in the supraclavicular fossa, mainly in the angle formed by the subclavian and internal jugular veins. The inferior lymphatic nodes are usually affected later than the superior. On the left side the proximity of the thoracic duct to the inferior nodes, and the possible danger of wounding it, must be kept in mind.

Technic.—A preliminary gastrostomy should be done to improve the patient's nutrition, increase his powers of resistance, and diminish the dangers of wound infection and other insults coincident with feeding through the cervical wound. The resection of the esophagus must be a circular resection in lines at least 2 cm. (4/5 in.) distant from each end of the carcinoma. The affected deep cervical lymphatic nodes, as well as those that are suspected of being involved, must be removed; whether this is done at the time of the main operation or later must be determined in the individual case. In advanced cases it may be necessary to remove the larynx and part of the trachea as well.

As a rule, an attempt should be made to restore the esophagus. For this purpose a large, broad skin flap from the neck is taken and turned upon itself, so as to form a tube, or rather a deep gutter, with the skin side inward. The 2 ends of this tube are sutured to the upper and lower divided ends of the esophagus. The esophageal tube is thus restored except at the side, where the edge of the flap turns back upon the flap. This part is tamponed; it is closed

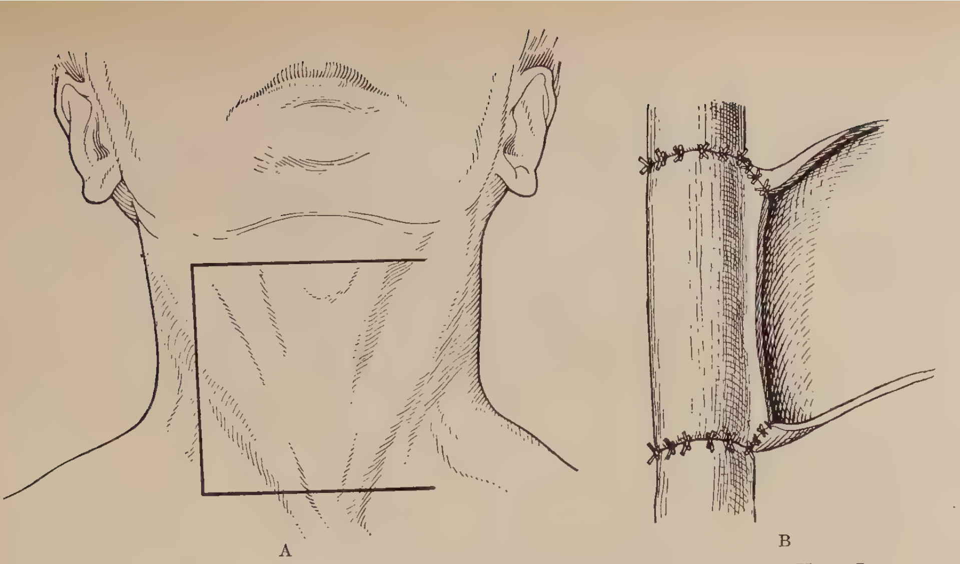


Fig. 7.—A—Diagram of Flap for Cervical Esophagoplasty; B—Flap Turned Upon Itself to Form a Tube. The surface of the skin forms the inner lining of the tube. Above and below, the free edges of the tube are sutured to the pharynx and esophagus respectively. Where the free edge meets the flap near its pedicle—right side of illustration—the tube is open. A part of the free edge is sutured to the upper and lower borders of the flap.

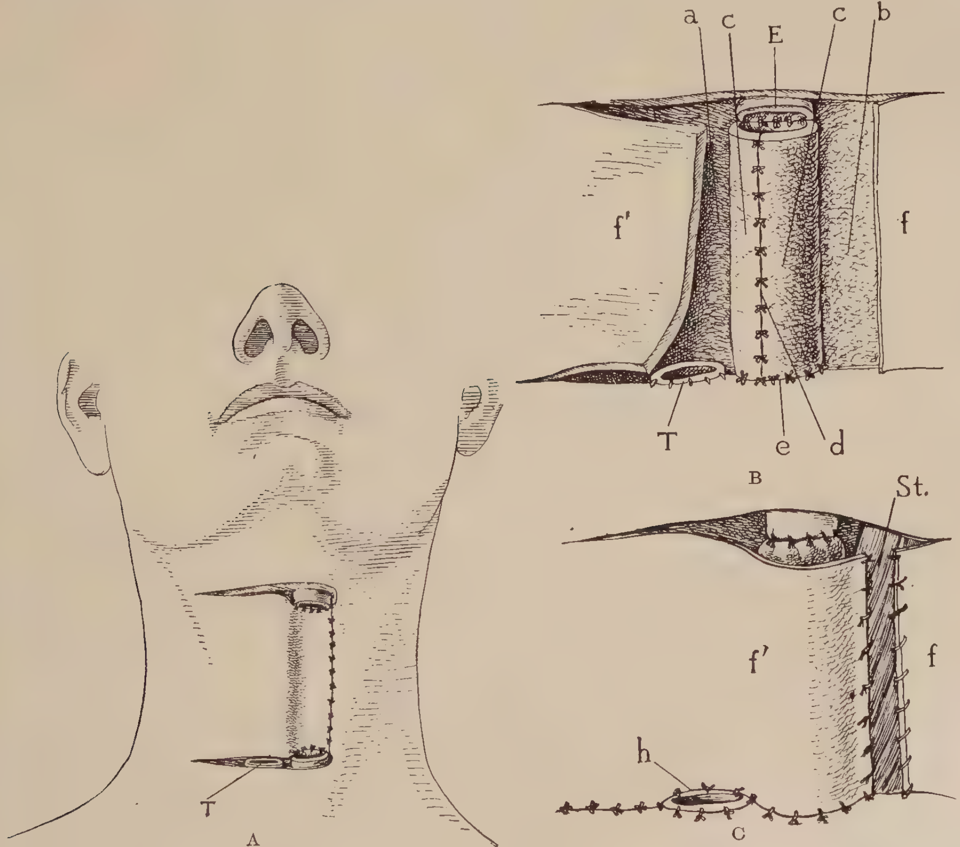


Fig. 8.—Diagram of Esophagoplasty According to V. Hacker. A shows gutter of skin to form posterior half of new esophagus; T, trachea. B—From surfaces a and b the flaps c-c, have been taken and joined to each other by suture d, the epidermis being inside; e, suture of newly made tube to anterior half of esophagus; f and f′, flaps for covering new tube; T, trachea; E, esophagus, still open in anterior portion. C—f′, larger flap, f, smaller flap, both of which are sutured to St, the sternocleidomastoid muscle; h, suture of flap to trachea.

about 2 weeks later. The diagrammatic representations in Figure 7, A and B, show one method of forming the flap.

The esophagus may also be restored according to v. Hacker's method. In the first act the skin flap is placed into the depth of the wound to form the posterior wall of the esophagus (Fig. 8, A). The posterior halves of the upper and lower esophagus stumps are sutured to the upper and lower borders of the flap respectively. In the second act a skin flap is shaped on each side of the newly made posterior wall of the esophagus, and the 2 flaps are turned toward each other, edge to edge, and united to form a tube (Fig. 8, B). This tube, in turn, is covered by lateral skin flaps (Fig. 8, C) mobilized for the purpose.

Dangers.—The dangers of the operation are injury to the recurrent laryngeal nerves, the jugular and subclavian veins, and the thoracic duct, wound infection causing sepsis or peri-esophageal phlegmon and mediastinitis.

Causes of Failure.—The most frequent immediate causes of failure are insufficient nutrition and resistance of the patient, cardiac failure, pneumonia, exhaustion, and wound infection. Failure to achieve permanent results is due to the advanced stage of the affection, many cases having progressed beyond the esophagus, especially on the larynx and trachea, and to the failure to remove all affected lymphatic nodes.

Results.—The mortality is about 36 per cent. Only 1 case (v. Hacker's) was free from recurrence for 1½ years at the time when it was reported. All others succumbed to recurrences.

2. Resection of the Thoracic and Abdominal Portions of the Esophagus

Previous to the era of intrathoracic surgery under differential pressure it was the aim to attack the esophagus by entering the posterior mediastinum without injury to the pleura. These procedures will be referred to under Operations on the Posterior Mediastinum. The danger incident to pneumothorax caused by opening the pleural cavity compelled the surgeon to select the extrapleural route. However, since there now exist methods of keeping the lungs inflated to any desired degree, while the thorax is open, the transpleural route of access to the esophagus is preferred.

Before describing transpleural resection of the esophagus, it will be necessary to discuss some matters common to all intrathoracic operations.

General Remarks on Intrathoracic Operations.—PNEUMOTHORAX.—The opening of the chest cavity naturally causes pneumothorax, which, if bilateral, invariably proves fatal. If only one side is opened, a fatal outcome does not always result. In the case of bilateral pneumothorax death ensues, because both lungs collapse and oxygen is not supplied to the blood, so that the patient dies from carbon-dioxid intoxication. In cases of unilateral pneumothorax the disturbance was explained by Sauerbruch as follows: The collapsed lung permits more blood to pass through it than the expanded lung. The collapsed lung, being hyperemic, therefore, deprives the normal lung of some of its share of blood. Hence the normal lung cannot oxygenate its normal amount of blood, as it does not receive its full share, and the collapsed lung returns the blood to the left heart unoxygenated.

This explanation, however, has been disproved by others who have shown that the collapsed lung, instead of being hyperemic, on the contrary contains less blood than the normal lung. The sum total of the blood in both lungs is less than in the normal condition, and, of course, the collapsed lung does not arterialize the blood passing through it. So we have lack of oxygen and intoxication with carbon dioxid, the same as in bilateral pneumothorax, and death may, therefore, be due to the same cause.

Another factor that has a bearing on insufficient arterialization of the blood is to be found in the relation of the tension of the expanded lung to the diastolic expansion of the heart. The collapse of a lung is accompanied by a somewhat diminished diastolic expansion of the heart, especially the right heart, so that the amount of blood propelled by the heart is diminished. This latter observation is of practical importance in operating under differential pressure. If the heart becomes weak, while the lung is collapsed, it is well occasionally to dilate the lungs more thoroughly to encourage improvement in the quality of the pulse.

The most important factor that enters in causing insufficient arterialization of the blood is a diminution in the excursion of the unexposed lung. Whenever, on an inspiratory movement, the diaphragm descends and the chest wall expands, the position of the mediastinum will change. Inasmuch as this partition between the two pleuræ is movable, it will deviate, on inspiration, toward the side where the negative pressure is, that is, toward the unopened side, so that the lung is incapable of expanding to its normal extent. The expiratory movement is similarly deficient, as the mediastinum then gives way to the pressure from within and is forced to the opposite, the open, side. Consequently the lung is neither sufficiently filled on inspiration nor sufficiently emptied during the expiratory movement. There is also a certain amount of to-and-fro breathing between the two lungs, the expired air from the better lung being to some extent forced into the collapsed lung and breathed back again on inspiration. Of course, the air thus passing from lung to lung does not become oxygenated. The to-and-fro movement of the mediastinum is termed "mediastinal fluttering."

The displacement of the mediastinum in unilateral pneumothorax also hinders respiration mechanically, for the mediastinal pleura on the unopened side is under especial tension and draws upon the hilus of the lung. The hilus, however, is prevented from yielding to this traction by the pleural duplicature known as the pulmonary ligament, which does not give way. The large bloodvessels which accompany the air tubes may also share in obstructing the bronchus by tugging in the opposite direction from that toward which the mediastinum is drawn, as they are more or less fixed through their connection with the aorta, which is the least movable of the mediastinal structures. There is, therefore, a variable degree of kinking of the bronchus caused by the displacement of the mediastinum. This is even more marked on the left side than on the right, as the left bronchus forms a less obtuse angle with the trachea than the right bronchus and the arch of the aorta lies directly on it. This is probably one of the reasons why right pneumothorax is more dangerous than left, others being that the right lung is larger and that in right pneumothorax the vena cava and the right auricle tend particularly to collapse, thus rendering the aspiration of venous blood into the heart more difficult.

The respiratory difficulty is considerably less if the opening through which the air gains access to the pleural cavity is small. If this opening is smaller than the glottis, the air can more easily enter the lungs than the pleura, and the lung is, therefore, able to expand to some extent. Furthermore, if the mediastinum is fixed by pleural thickening, as in empyema, the respiratory distress is also much diminished.

To overcome the harmful results of pneumothorax there are various methods at our disposal. In the absence of various apparatus, to be mentioned later, for accomplishing dilatation of a collapsed lung, traction is made on it till it is brought in contact with the thoracic wall. This at once overcomes the dangerous dyspnea, a result brought about by steadying the mediastinum.

It makes a great difference whether the pneumothorax is produced rapidly or slowly. In the latter case serious symptoms may be entirely absent, and the disturbance is always much less than where pneumothorax is brought about quickly. The explanation lies in the fact that the respiratory movements of the normal lung and the alteration in the pulmonary circulation have time to adapt themselves to the newly established conditions. Moreover, a slowly produced pneumothorax need not necessarily be complete but may be partial.

These considerations lead us to take cognizance of two important principles in the management of pneumothorax occurring in the absence of apparatus for expanding the lungs. 1. If the pleura is opened accidentally or purposely, the air should be allowed to enter slowly by promptly pressing gauze against the wound. Of course, if possible, we close a pleura that has been opened accidentally. 2. If the thorax is opened widely, the lung should at once be seized and drawn toward the chest wall and provisionally fastened there, after the necessary examination and palpation of the lung has been made.

If a wide opening of the pleura is necessary in cases where the nature of the pulmonary affection has been definitely determined previously and an incision, as in abscess, is indicated, a preliminary pneumopexy is made, before the pleura is opened, the lung being stitched to the pleura at some distance from the periphery of the diseased area. In suturing the lung to the parietal pleura it is necessary to include muscle with the parietal pleura and lung tissue with the visceral pleura.

The greatest progress in overcoming the dangers of pneumothorax was made by Sauerbruch, who instituted the method of opening the thorax under diminished pressure, while the patient was breathing air under normal pressure. Brauer later accomplished a similar result by increasing the pressure of the inhaled air. He placed the patient's head in a chamber in which the air pressure was increased, while the patient's body was under normal pressure. The first of these methods is known as operating under negative pressure, the second, operating under positive pressure.

Both are included under the term "differential pressure." There is still another method of supplying air to the lungs when the thorax is open, namely that of intratracheal insufflation (Meltzer-Auer), by which the anesthetic or air is conveyed into the trachea by means of a catheter introduced through the larynx. For a description of these the reader is referred to the chapter on Anesthesia. The last of these methods, that of intratracheal insufflation, is the favorite in this country. In operations for exudates in the pericardium and mediastinum, the negative pressure method is especially indicated. The method of positive pressure has also been modified in a variety of ways by applying it through the medium of a well-fitting mask attached firmly to the face (Tiegel and others). In this manner, Sauerbruch and those who followed in his footsteps have shown the way to overcome one of the greatest dangers of intrathoracic surgery.

PREPARATION OF PATIENT.—The preparation of a patient for an intrathoracic operation, while not essentially different from that in other major operations, requires special attention to certain details. The examination of the heart function is important. Chronic myocarditis is especially dangerous; arteriosclerosis of the peripheral vessels less so. Cardiac insufficiency requires the exhibition of digitalis for a few days before operation. Anemia calls for iron and quinin. Even slight catarrhal affections of the lungs require careful pre-operative treatment, such as moist packs and expectorants, possibly in combination with cardiants. Inhalations are efficacious in facilitating expectoration. Existing nose and throat affections should receive appropriate treatment.

ANESTHESIA.—Local anesthesia may be employed in extrapleural operations. It is preferable, also, in cases of abscess or gangrene of the lung if pleural adhesions exist or have been artificially produced. The lung tissue itself is not sensitive to pain. Narcosis in these cases favors aspiration pneumonia. Intrathoracic operations, however, with free opening of the pleura, require general anesthesia. Irritation of the vagus is much more dangerous in the conscious state than under narcosis. Under differential pressure the patient requires very little anesthetic. A preliminary morphin injection should be given, and its administration should also be continued for a few days after operation.

TECHNIC.—As regards the technic itself the following may be said: Most intrathoracic operations are begun with an intercostal incision. Differential pressure is not needed in dividing the skin and muscles. To divide the pleura it is desirable that a moderate degree only of intrapulmonary pressure be employed, so that the lung may collapse to an extent to recede from the knife and escape injury. Moreover, the knife must be handled with proper caution to avoid sudden entrance into the lung, as the pleura is divided. Then a rib spreader is introduced (Mikulicz's, Sauerbruch's, or Torek's, or a strong, self-retaining abdominal retractor). When the thorax has been widely opened, an examination is made, first by inspection, then by palpation with the whole hand in the pleural cavity. The surface of the lung can be best examined for injuries or tumors if it is fairly well expanded; but for operating on the lung a moderate degree of collapse is more favorable. A minimum of inflation is desirable in operating on the esophagus and the large vessels, otherwise the lung is in the surgeon's way. If the patient's breathing is unsatisfactory, the lungs may be alternately inflated and allowed to collapse, producing artificial respiration.

To close the thoracic cavity, the 2 adjacent ribs are approximated by sutures of strong silk. This is done either by carrying them around the ribs—pericostal suture (Fig. 9)—or through holes punched in the ribs with Friedrich's rib punch—percostal suture. On tying the sutures, the lung should be completely expanded, so as to come in contact with the parietal pleura. The soft parts are then closed air-tight.

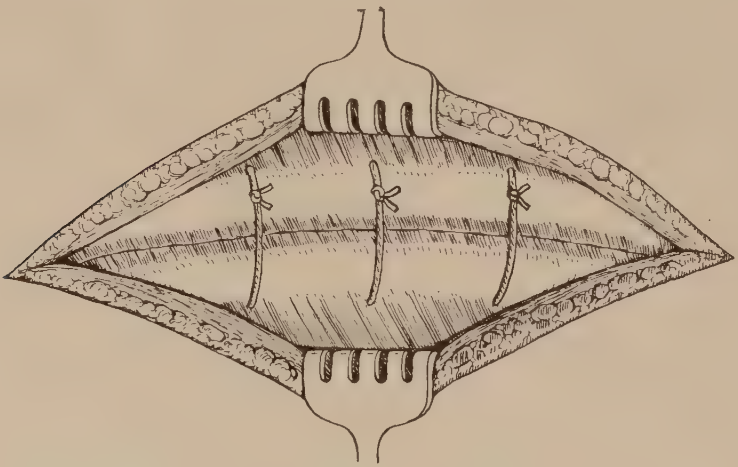


Fig. 9.—Pericostal Suture. Strong silk is used.

Drainage is to be avoided whenever possible. It should be employed only if the pleura has been infected or we have good reason to believe that it will be. If there is any doubt, the pleura should be closed at the end of the operation and drained later, if necessity arises. If we do drain, gauze is preferred. The skin around the drained wound is covered with zinc-oxid ointment, and a rubber dam is placed over the dressing to render it air-tight. Or the gauze drain may be made to pass out through an oblique canal, the opening through which it emerges from the skin being placed a hand's breadth away from the opening at which it leaves the thoracic cavity. Between these 2 openings a canal is made by undermining the skin and muscles.

Indications for Intrathoracic Resection of the Esophagus.—Carcinoma of the esophagus without metastases is the indication for intrathoracic resection.

The abdominal organs, especially the liver, stomach, and retroperitoneal lymphatic nodes, are searched for the presence of metastatic carcinoma at the time when the preliminary gastrostomy is done. If metastases are present, the intrathoracic operation is not to be considered. In the absence of metastases the operation is to be undertaken, unless the patient continues to decline after the gastrostomy. An extension of the carcinoma upon the neighboring organs, aorta, bronchi, lungs, etc., may render the operation impossible. This question, however, will, as a rule, not be decided until the thorax has been opened.

Anatomical Points.—Besides the anatomical points mentioned under Introduction of Sounds, the following should be noted: In the upper part of the thorax the esophagus lies behind the trachea, about in the median line. Near the bifurcation of the trachea the arch of the aorta crosses in front of it and the trachea. At the bifurcation the esophagus lies mostly behind the left bronchus, the rings of which are incomplete where it rests against the esophagus. At this part of its course the aorta begins to insinuate itself behind the esophagus, lying now behind but more to the left of the esophagus. Below this point the posterior wall of the pericardium lies in front of it. In the lower part of the thoracic cavity the esophagus deviates decidedly to the left of the median line and crosses in front of the aorta. The thoracic duct lies behind the esophagus in the upper part of the thoracic cavity; lower down, where the aorta pushes the esophagus forward, the thoracic duct lies behind the aorta.

The relation of the pneumogastric nerves to the esophagus is important. It interests us more particularly from the arch of the aorta downward, as the nerves here are much closer to the esophagus than they are farther up in the thorax. The left vagus lies on the left and anterior wall of the esophagus; the right nerve lies more posteriorly. As a rule, in the lower half of its intrathoracic course the pneumogastric nerve ceases to be a single nerve and divides into a number of anastomosing nerves forming the anterior and posterior esophageal plexuses.

Instruments Used.—Besides the usual instruments, a number of long instruments are requisite for that part of the operation which is done in the depth. The following are suggested: A long, curved dressing forceps; a number of long, curved artery clamps; Foerster's sponge holders; Kocher's blunt dissector (goiter sound); long, curved Mayo's dissecting scissors; 2 long anatomical forceps; 2 long surgical forceps; a crushing forceps; rib shears; and Sauerbruch's lung retractors. For holding the ribs apart a number of rib spreaders are in use. I have had much better satisfaction with an instrument that was not designed for the purpose, viz., Balfour's abdominal retractor. This consists of 2 parts, the main part being the spreader. I have adapted this for this purpose by remodeling it so as to spread 5 cm. (2 in.) farther (Fig. 10). For suturing in the depth, a long, slender needle holder is of advantage. One model, which is not only long and exceedingly slender, but also very light though strong, is represented in Figure 11. The needle can be held in it at any desired angle. It has, however, no catch to lock its 2 arms together and will, therefore, not appeal to those who are dependent upon that device.

Technic of Operation.—The first successful resection of the esophagus for carcinoma of its thoracic portion was performed by Torek on March 14, 1913, and at the present writing, 18 months after the operation, the patient is alive and well. The carcinoma was situated in the middle portion of the esophagus, that part which had hitherto been considered to be the least favorable for operation. At that site, however, carcinomata occur more frequently than at other parts of the esophagus and are less liable to early metastases than those at the lower end. They therefore deserve the surgeon's particular attention. The diagnosis as to presence, localization, and character of the tumor is made with the aid of sounds, X-ray examination, and esophagoscopy, described in other chapters.

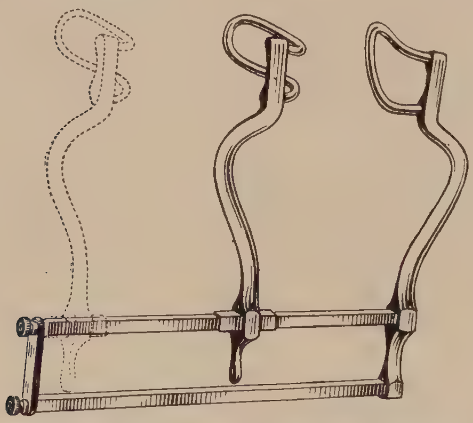


Fig. 10.—Torek's Rib Spreader Modeled After Balfour's Abdominal Retractor. Used for spreading the ribs.

The operation is performed in 2 stages: In the first stage gastrostomy by Witzel's or Kader's method is performed (see chapter on Stomach); in the second stage the esophagus is resected. At the first stage the abdominal cavity is carefully examined for metastases in the liver, retroperitoneal glands, stomach, etc. In the presence of such metastases, gastrostomy only is performed, the case not being suited for resection of the esophagus. In the second stage, the resection of the esophagus, the important principle is to avoid leaving anything in the mediastinum and pleural cavity that may become a source of infection, such as an insecure gastro-esophageal anastomosis or a closed oral esophageal stump, the stitches of which may give way. To avoid these sources of infection, the esophagus, or at least its proximal portion, is removed from the thorax altogether. Furthermore, in order to be able to perform the necessary dissection neatly and without injury to important structures, liberal access is necessary. This is obtained by cutting through the entire

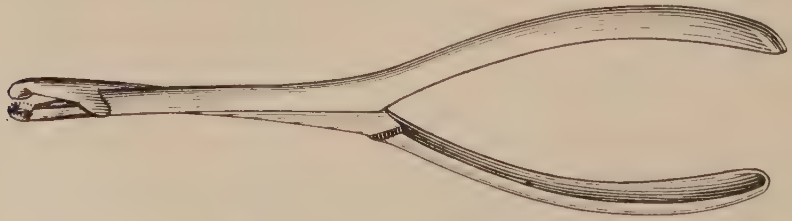


Fig. 11.—Torek's Needle Holder.

length of the seventh left intercostal space and posteriorly extending the incision upward through the seventh, sixth, fifth, and fourth ribs by cutting through them between their angles and tubercles. This incision gives excellent exposure.

The preparation of the patient is similar to that described under General Remarks on Intrathoracic Operations (page 507). The operative procedure is as follows: The patient lies on his right side, with his left arm up and well forward, so that the scapula is out of the way of the line of incision. An incision corresponding to the entire length of the seventh intercostal space is made through skin and muscles down to the pleura but not through it; for it is desirable that the pleural cavity does not remain open for an unnecessarily long time and that the hemorrhage from the external wound is attended to before the pleura is opened. From the posterior end of the seventh intercostal space, between the angle and the tubercle of the rib, the incision is carried upward to the third intercostal space (Fig. 12). Skin and muscles are divided, exposing the fourth, fifth, sixth, and seventh ribs. As it is of the greatest importance to preserve the asepsis of the pleural cavity, and as the wound is so large that the possibility of infection from the surrounding parts is greater than in an ordinary wound, the wound is isolated by fastening towels to the edges of the incision with the aid of skin clasps. To insure complete hemostasis it will be found necessary to clamp and tie a great many vessels. This first step of the operation may be performed under general or local anesthesia. I prefer the latter, using a ½ per cent. solution of novocain with suprarenin. Then, while the vessels are being ligated, general anesthesia is induced. As soon as the patient is under the influence of the anesthetic the larynx is intubated for intratracheal insufflation anesthesia (see Vol. I, Chap. III). In this way the time during which the patient is under general anesthesia is shortened.

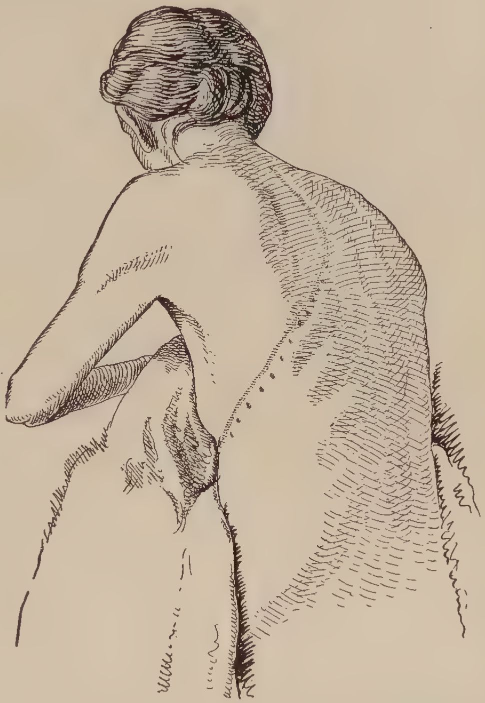


Fig. 12.—Torek's Case of Resection of Esophagus, Showing Skin Incision. Anterior end of incision seen in Figure 15.

Anesthesia is now continued by intratracheal insufflation, and the pleura may be opened without the fear of dangerous collapse of the lung. The pleura is divided the entire length of the seventh intercostal space, and an examination is made to determine the operability of the tumor. If we decide to proceed, we now complete the posterior, vertical part of the incision, which requires the division of the seventh, sixth, fifth, and fourth ribs between their angles and tubercles, the intercostal muscles, the intercostal vessels, which must be caught and tied, and the intercostal nerves. The rib spreader (Fig. 10) is now placed between the seventh and eighth ribs, with the handle directed downward and forward and spread as far as necessary. Its full spread, 17 cm. (6¾ in.), will be required only in very large chests.

We now have a thorough view of the whole left pleural cavity, and if at the preceding examination there still existed a doubt as to the operability of the tumor, this question is definitely settled at this time. If the tumor has already involved any of the neighboring organs—aorta, bronchi, lungs, thoracic wall—its removal is not advisable, unless the extent of that involvement is so limited that it can also be removed. If, in tumors of the upper half of the thoracic esophagus, we can determine that both vagi are involved, this is also a contra-indication against operating, as the innervation of the heart might be endangered. In tumors lower down a resection might be attempted, even if both vagi are involved.

First we proceed to free the lung thoroughly of all adhesions. This must be done with the utmost care to prevent tearing or cutting the lung. The lung is then laid over toward the front part of the mediastinum and is kept only partially inflated. A full inflation is unnecessary and interferes with the surgeon's work. The use of lung retractors is, as a rule, not recommended. The less the organs are handled, the better. If the lung is inflated to such a degree as to render a retractor necessary, then its use is dangerous; if to the pressure within the lung a pressure from without is superadded, rupture may result, causing the dreaded postoperative pneumothorax. However, if the opposite pleura is opened in the course of the operation, a more energetic inflation of the lungs is required, as we cannot permit both lungs to collapse. Lung retractors are then needed.

As we stand facing the head of the patient, who is lying on his right side, we see as prominent features in the lower part of the thoracic cavity the aorta to our right and the pericardium to our left, the esophagus lying between them. (It will be remembered that in this region the aorta lies behind the esophagus and the pericardium in front of it.) The esophagus is seen only as a slight bulging of the parietal pleura to the side of the aorta. The pleura and connective tissue covering the esophagus are now divided at some portion where it is not involved, and the esophagus is lifted out of its bed. A tape or strip of gauze is drawn through underneath it (Fig. 13). This serves as a handle to draw the esophagus forward or to the side, while the dissection proceeds.

The esophagus is liberated from the surrounding structures all the way up to the upper thoracic aperture and all the way down to the diaphragm, except in cases where the tumor is situated rather high up, when the diaphragmatic end need not be liberated. To determine the extent of the dissection at the diaphragmatic end, we decide at what place below the tumor the esophagus is to be divided, and allow about 3 cm. (1¼ in.) more for invagination of the lower stump. The dissection is best done with the aid of a blunt instrument like Kocher's goiter sound, which is inserted between the esophagus and the tissues lying over it. The fact that some vagus branches crossing the esophagus must be divided in the course of this procedure need not deter the surgeon. The main vagus cords will be seen as described under Anatomical Points. Their liberation from the esophagus is accomplished preferably, not by picking them up with forceps and dissecting them out with scissors or knife, as one would do in the dissecting room, but by keeping close to the esophagus and leaving the vagi in their places. An anatomical dissection of the vagi becomes necessary when they are firmly bound down to the tumor. In that case, the one that is less firmly attached is loosened; the other one may be cut. In a general way, the less they are handled, the better. Sudden and irreparable collapse has resulted from pinching them or tugging at them.

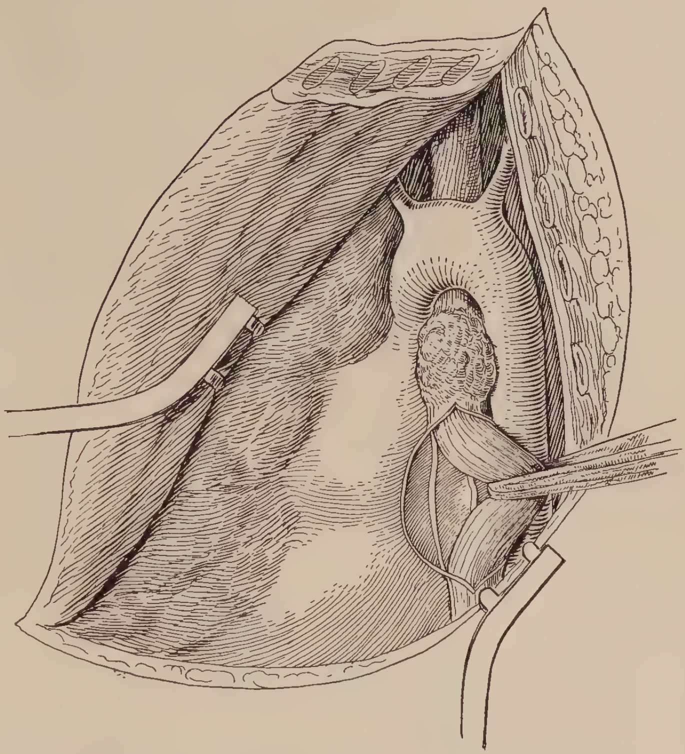


Fig. 13.—Thorax Opened by Torek's Incision. A portion of the esophagus below the tumor has been exposed by incision of the mediastinal pleura and connective tissue, liberated from the surrounding tissues, and drawn out of its bed with the aid of a tape passed under the liberated portion. The tape serves to steady the esophagus during further dissection.

The dissection of that part of the esophagus which crosses under the arch of the aorta is not easy. It is done by blunt dissection with the finger introduced under the arch of the aorta and loosening the esophagus from it and the left bronchus, as well as from its posterior attachments. During this part of the dissection one must be careful not to tug hard on the aorta. The right heart is already working at a disadvantage, as the partly collapsed lung offers more resistance to it than a well-inflated lung; add to this an obstruction to the function of the left heart by pressure on the aorta, constricting its lumen, and a

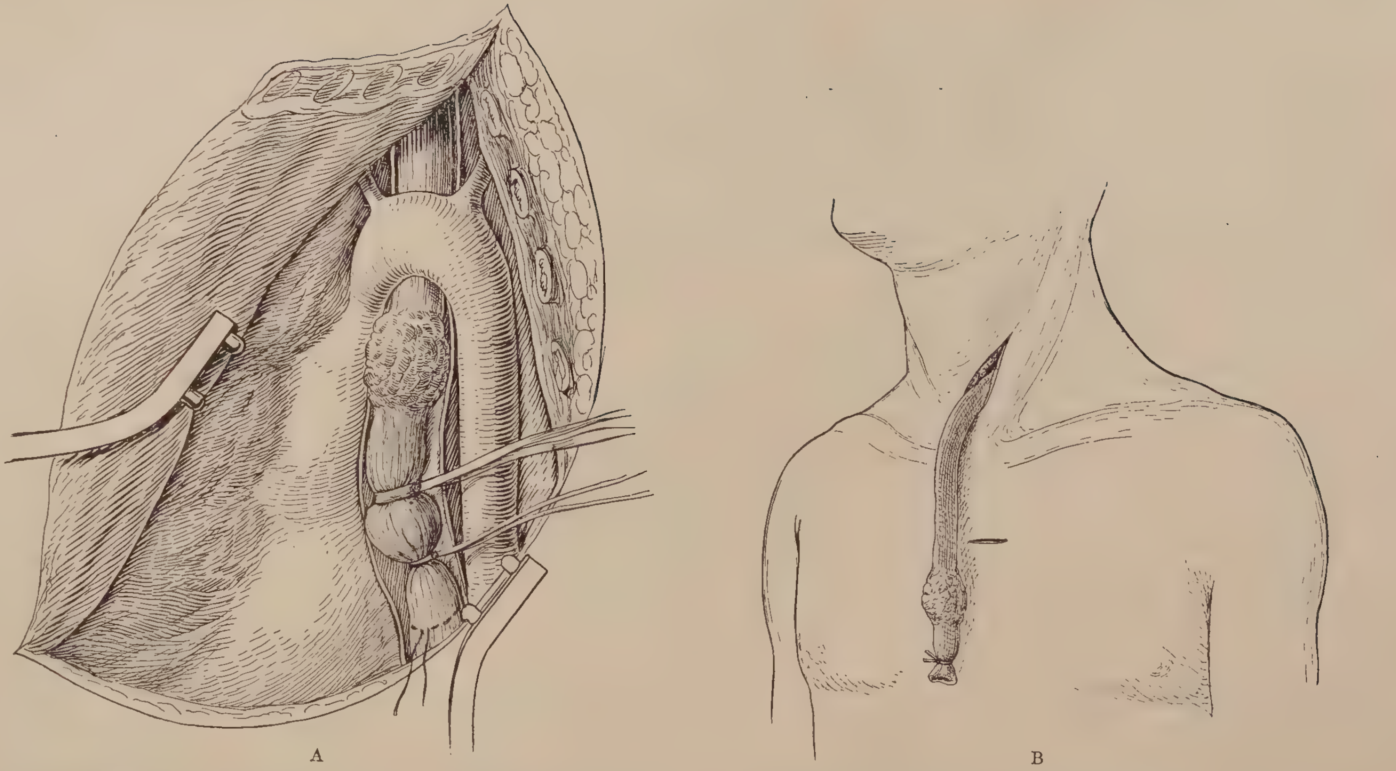


Fig. 14.—Resection of Esophagus. A—The esophagus is doubly tied before being divided. Strong silk used for upper ligature. To facilitate invagination of lower stump thinner silk or catgut is employed for the lower ligature the site of which is also previously crushed. Below the lower ligature a purse-string suture is placed to close the esophagus after invagination of the stump. B—The esophagus with the tumor attached is brought out through the neck at the border of the sternomastoid muscle. It is then placed under the skin from which it emerges again at the transverse incision on the thorax. The tumor is then amputated and the end of the esophagus sutured to the skin, after which the neck incision is closed.

cardiac collapse is apt soon to manifest itself. If the tumor itself is situated in the neighborhood of the aortic arch, as in my above mentioned case, the difficulty of liberating the esophagus becomes very great. I overcame this difficulty by ligating and dividing a number of the thoracic branches of the aorta and lifting that vessel forward. Here again, in retracting the aorta, one must be careful not to kink it, as the cardiac action will suffer in consequence. The dislodgment of the aorta is of great value in liberating the esophagus; but in simpler cases, where the tumor did not lie near the arch, I found this procedure unnecessary. Above the arch a tape is again carried around the esophagus to serve as a handle for further upward dissection. When the upper thoracic aperture is reached, a finger is carried through it into the neck to the anterior border of the sternocleidomastoid muscle. Here, under its guidance, an incision is made through which the esophagus is afterward to be brought out; for the time being, a stout silk thread is carried into the pleural cavity through this wound, one end being left outside, to serve for pulling out the esophagus.

Before proceeding to divide the esophagus, the surrounding parts are well protected by gauze pads. The esophagus is tied off with a strong silk ligature at a safe distance below the tumor, and a second ligature is applied a sufficient distance below the first to enable one to cut the esophagus between them without danger of the ligatures slipping off (Fig. 14, A). As the lower one of these ligatures is afterward to be invaginated into the lumen of the esophagus, catgut is used, and the site where it is to be applied is first crushed to reduce the mass held in the ligature. To facilitate invagination, furthermore, a thinner ligature than for the upper ligation is selected. Before dividing the esophagus, a purse-string silk suture is inserted 1 or 2 cm. (about ½ in.) below the lower ligation. If the site of the carcinoma is so low that there is not sufficient room to insert the invagination sutures beneath the site selected for ablation of the esophagus, the stomach must be brought up into the thoracic cavity far enough to afford the necessary space for putting in the sutures. This is done by splitting the diaphragm and peritoneum in front of the hiatus, with careful ligation of vessels, sufficiently far forward to permit the upward dislodgment of as much stomach as necessary. The left gastric artery is divided if it interferes with drawing the stomach upward. Without dividing the diaphragm, the esophagus may be drawn up into the thorax for 1 or 2 cm. (about ½ in.) after it has been loosened at the hiatus. The esophagus is now divided between the 2 ligatures, and the mucosa of the upper stump is cauterized with a Paquelin cautery or with carbolic acid. If the crushing of the lower stump has been extensive enough, there will be no mucosa in it; if any remain, it is trimmed off or cauterized. The lower stump is now invaginated and secured by the purse-string suture previously introduced; and, if possible, a second purse-string suture invaginates the stump still further. If the diaphragm had been divided, it is now accurately sutured. The upper stump is pushed through the channel beneath the arch of the aorta, and the ligature at its end is tied to the silk thread which had been introduced into the pleura through the neck incision. The esophagus, with the tumor attached, is now drawn out through the neck wound (Fig. 14, B). There it is allowed to remain for the present, wrapped in gauze.

We next proceed to close the chest. A few sutures of strong silk are placed to hold the seventh and eighth ribs in apposition. These sutures are carried around the 2 ribs—pericostal suture (compare Fig. 9)—or they may be carried through the ribs after punching holes in them. No attempt is made to reunite the ends of the cut ribs; they fall in line of themselves. The muscles are united in layers by catgut sutures. Before making the suture air-tight, the lung is thoroughly inflated to bring its surface in contact with the parietal pleura. There exists in the minds of many surgeons a great fear lest some air be allowed to remain in the pleural cavity, as evidenced by numerous articles that have been written to set forth the difficulty of completely doing away with the pneumothorax. I am convinced that a small amount of air left in the pleural cavity is entirely harmless. The experiments of producing artificial pneumothorax as a method of treating tuberculosis of the lungs have furthermore shown that air introduced into the pleural cavity is very rapidly absorbed. The suture of the skin completes the closure of the thoracic wound.

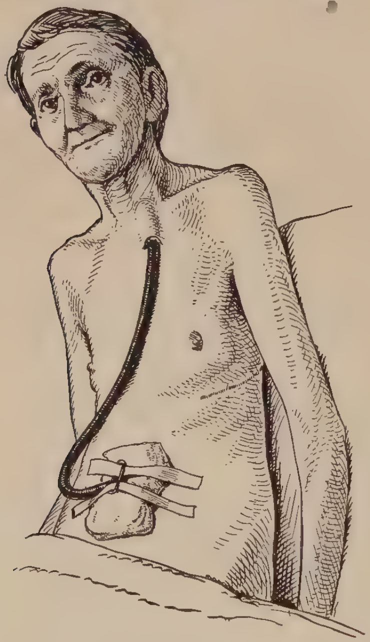


Fig. 15.—Resection of Esophagus for Carcinoma. The gastrostomy tube is introduced into the stump of the esophagus in the upper part of the chest for purposes of feeding.

We now again turn our attention to the esophagus, which, with the tumor at its end, hangs out from the neck. We hold it down over the front of the chest, estimate where it is to be amputated, and make a transverse incision through the skin at the site corresponding to this point (Fig. 14, B). Then the skin between the neck wound and the new incision on the chest is undermined with a blunt instrument, and the esophagus, still unopened, with the tumor attached, is drawn through this tunnel and out through the new wound. The incision in the neck is closed, the tumor amputated, and the free end of the esophagus sutured to the skin by a few interrupted stitches.

The most comfortable position for the patient after operation is partly on the right side and partly on the back. Morphin is given for a few days, and stimulation is administered according to the usual indications. Camphor, caffein, digalen, and strophanthus are given for acute cardiac weakness. Nourishment is given through the gastrostomy tube. After the free end of the esophagus has thoroughly healed to the skin, the upper end of the gastrostomy tube is inserted into it, when the patient wishes to take nourishment (Fig. 15). During the act of swallowing a little pressure is brought to bear on the skin at one side of the tube to prevent leakage. A fairly large tube is selected. The swallowed food passes from the esophagus into the rubber tube and thence into the stomach.

Operation for Carcinoma of the Abdominal Portion of the Esophagus.—In carcinoma of this portion, which usually also involves the cardiac end of the stomach, I recommend operating in 3 stages: 1. Gastrostomy. 2. Thoracotomy, as described above for carcinoma of the thoracic esophagus. After division of the esophagus in its lower part, the upper end is brought out at the neck, as described above, and the lower end is invaginated and placed beneath the diaphragm which is closed by suture. 3. An abdominal operation to resect the tumor. Incision is made from the ensiform cartilage along the entire length of the left costal arch, thoroughly dividing the abdominal muscles, particularly at the posterior end, so that the costal arch can be well raised. At the esophageal hiatus of the diaphragm the peritoneum is divided and the stump of the esophagus is brought down. Then the tumor is resected, removing as much of the stomach as is indicated.

Other Methods of Resecting the Esophagus.—Zaaijer was the first to operate successfully in a case of carcinoma of the cardia by the transpleural route. In his case the esophageal bougie was halted at 45 cm. (18 in.) from the incisors, an exceptionally long distance. He operated in 3 stages. 1. Gastrostomy at the pyloric portion, Kader's method. 2. Extensive rib resection in order to cause collapse of the thorax and thereby to bring the lower portion of the esophagus and cardia nearer to the surface of the body, thus reducing considerably the depth at which the main operation is performed. The lowest 7 ribs of the left side are resected in almost their entire length through 2 parallel incisions about 25 cm. (10 in.) long; the superficial musculature is extirpated; the skin sutured. Zaaijer's patient had considerable dyspnea the first 2 days following operation. He believes this due to mediastinal fluttering caused by the great mobility of the thorax, and he therefore recommends leaving the twelfth rib or at least not removing it at the same sitting. 3. Resection of the tumor by laparothoracotomy. The skin incision is made in the left hypochondrium about in the mammillary line, thence in a curvilinear direction backward to the posterior axillary line, thence upward a little higher than the angle of the scapula. Peritoneum and pleura are opened. The diaphragm is divided from below upward to the hiatus. Esophagus and stomach are made movable; the lesser omentum is divided. The stomach is then divided between 2 clamps, and the lower end is sutured. The esophagus is drawn to the skin in the neighborhood of the posterior axillary line and sutured there. The end of the esophagus and the gastric fistula are connected by a rubber tube. According to Zaaijer, the operation is limited to carcinoma of the cardia and of the very lowest portion of the esophagus.

The remaining methods will be mentioned only in outline, as they have thus far all resulted in failure. Sauerbruch's invagination method in carcinoma of the cardia is performed in 2 stages. At the first stage the pleura is opened through an intercostal incision, the esophagus is isolated, the diaphragm incised, the stomach drawn up 3 to 5 cm. (1 or 2 in.), and the esophagus with its tumor is invaginated into the stomach, which is sutured circularly to the esophagus. Accurate suture of the diaphragm is made. The second stage, performed 10 to 14 days later, consists in a gastrotomy, seizure of the invaginated portion between 2 fingers introduced into the stomach, and its removal with long curved scissors. Bleeding is to be controlled by compression. This method could be employed only in cases of very limited invasion of the cardia, and, as the operator has to work while groping in the dark, it will scarcely appeal to those surgeons who appreciate the desirability of careful dissection under the guidance of the eye in cancer surgery.

For somewhat larger carcinomata of the cardia Sauerbruch recommends intrathoracic resection of the tumor and anastomosis of the esophagus and stomach by means of a button, Payr's or Tiegel's button being preferred. Tiegel's is a modified Murphy button consisting of 2 parts, while Payr's is a single button, or rather short tube, the outer surface of which presents 3 transverse circular elevations, between which there are 2 circular transverse depressions. These latter serve to give a hold to purse-string sutures placed in the organs to be anastomosed. The procedure in the case of the Payr button is as follows: Through an incision in the seventh intercostal space, the tumor and the adjoining part of the esophagus are isolated, the diaphragm is incised in its aponeurotic portion, and the upper part of the stomach is drawn into the thoracic cavity. Above the tumor the esophagus is tied over the lower furrow of a Payr's button previously introduced through the mouth, then the esophagus is divided below the button (Fig. 16, A). The tumor is resected, and the upper part of the stomach, from which it was removed, is sutured in 2 layers. A slit is made into the fundus of the stomach, a purse-string suture having been previously placed around this slit (Fig. 16, B). The divided esophagus with the button is now inserted into the slit, and the purse-string suture is tied over the lower furrow of the button, the same furrow on which the esophagus had been tied. A second purse-string suture is laid in the stomach and tied around the esophagus at the site of the upper furrow in the button (Fig. 16, B and C). The communication between the abdominal and thoracic cavities is closed by stitching the diaphragm to the stomach, part of which remains in the pleura.

This method of anastomosis, it appears, has some elements of danger. If the esophagus is tied on the button firmly enough to prevent it from slipping, there will almost certainly result necrosis of that portion of the esophagus distal to the ligature. This danger will be still greater at the upper furrow, where the suture has to hold both the stomach and the esophagus and must, therefore, be drawn rather tight. Besides this, there is the danger of an outflow of infectious material from the esophagus or the stomach, which is not easy to avoid at the depth at which one is operating.

The objection last mentioned also holds good for the Tiegel button (Fig. 17, A), which is a modified Murphy button; but there is not the danger of necrosis as with Payr's button. The 2 halves are introduced; the outer one into the fundus of the stomach, the inner one into the esophagus, and each is held there by a previously placed purse-string suture (Fig. 17, B). An obturator (Fig. 17, A), introduced into the upper half, serves to facilitate handling it and to occlude the lumen, while the other half of the button is being placed. The 2 halves are then connected, and by this procedure the purse-string suture on the esophagus is invaginated into the button (Fig. 17, C). Then the anastomosis and the button are invaginated into the stomach and held there by a second purse-string suture in the stomach lower down than the first (Fig. 17, D).

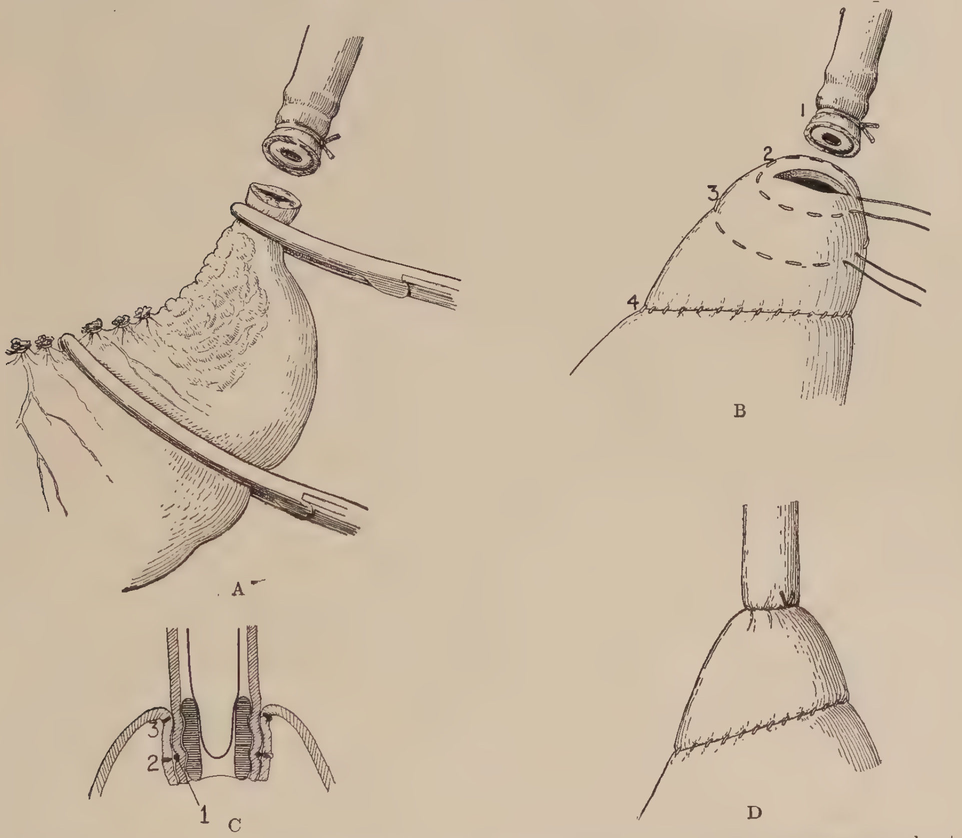


Fig. 16.—Anastomosis with Payr's Button. A—Esophagus tied to lower furrow of button and cut off below button. The cardia that is to be resected is clamped. B—1, ligature around esophagus; 2, first purse-string suture over slit in fundus of stomach, to be tied over ligature 1 holding esophagus; 3, second purse-string suture, to be tied over esophagus at upper furrow in button; 4, suture of stomach where cardia was resected. C—Section through button showing anastomosis. 1, 2, and 3 correspond to same numbers in B. D—Completed anastomosis.

For carcinoma in the upper part of the esophagus Sauerbruch recommends resection of the first, second, and third right ribs and costal cartilages from the sternum to about 3 cm. (1¼ in.) beyond the junction of rib and cartilage. The esophagus is found behind the trachea; it is isolated as in the operations on its lower part. After resection of the tumor, the lower end is invaginated and the upper end brought out through the neck. The patient is fed through a gastric fistula made some weeks previous.

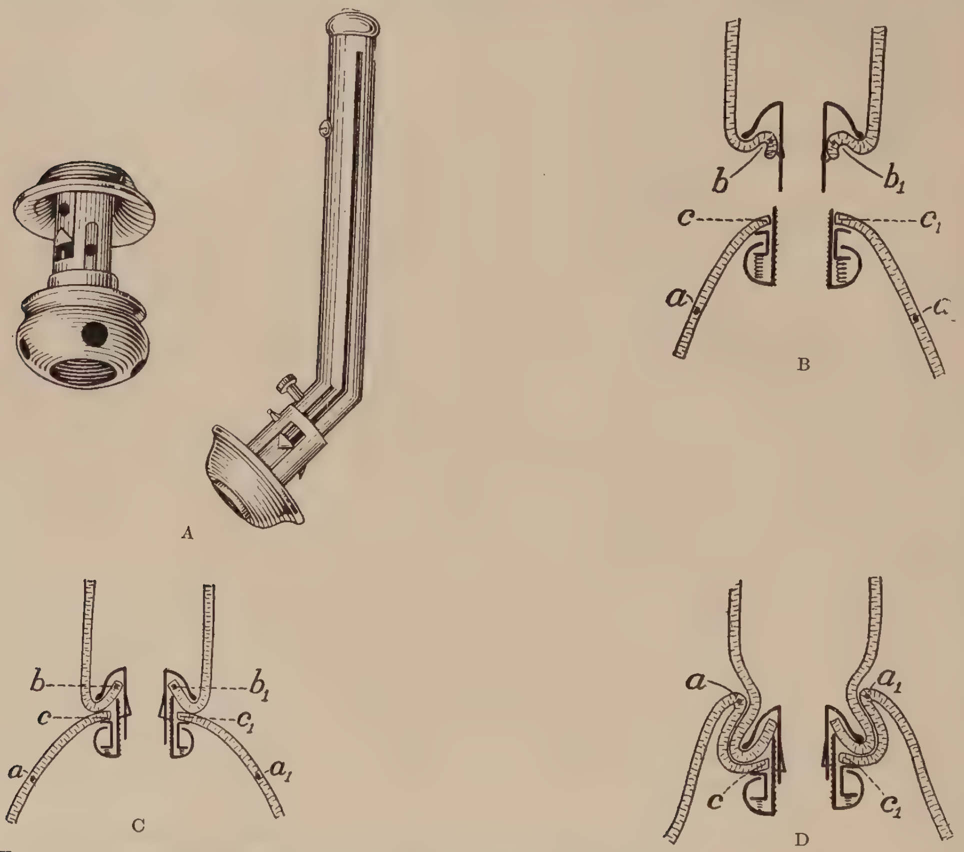


Fig. 17.—Anastomosis with Tiegel's Button. A—Tiegel's button and obturator. B—The two halves ready for anastomosis, b—b_1 purse-string suture of esophagus, c—c_1 first purse-string suture of stomach, a—a_1 second purse-string suture of stomach. C—The two halves united, the esophagus suture pushed up under hood of button. D—Button invaginated into stomach and held there by purse-string suture a.

Wendel recommends a combined abdominothoracic procedure in cases of carcinoma of the cardia. This consists in: laparotomy through the left rectus; if the case is favorable for resection, extension of the incision through the costal cartilages upward as far as the fifth; opening of the thorax; division of the diaphragm from the rectus incision backward through the *hiatus œsophageus.* This is mostly done by blunt dissection, except at the hiatus, where some fibers must be cut. The stomach and esophagus are then dissected out and brought forward. Resection and anastomosis now follow. On closing the diaphragm, it is sutured to the esophagus above the anastomosis, so that the suture line can be drained abdominally.

A very interesting method of operating in cases of carcinoma of the cardia has been proposed by Ach. The operation is done from the abdomen and from the neck without opening the thorax. At the anterior border of the sternocleidomastoid muscle the esophagus is exposed, and the wound is temporarily tamponed. Through an abdominal incision the peritoneal covering of the esophagus at the hiatus is divided, and, with the finger introduced into the hiatus, the esophagus is loosened as far as possible. A portion of the esophagus is now drawn down into the abdomen. It is tied off with strong linen thread about 2 cm. (4/5 in.) above the tumor and cut below the ligature. The 2 ends of the ligature are left about ½ meter (20 in.) long. A thin, flexible steel rod, 60 cm. (24 in.) in length, the end of which has the shape of a little ring, is introduced through the mouth down to the bottom of the esophagus. A needle armed with strong linen thread now transfixes the lower end of the esophagus and the ring; the thread is drawn through, and its ends are knotted together at a distance of about 12 cm. (5 in.) below the esophagus. The steel rod is now drawn up again; the thread held in its ring-shaped extremity follows and invaginates the esophagus into itself. According to Ach, it can be drawn up without encountering much resistance. As soon as the lowest part of the cervical esophagus is seen through the neck incision to become invaginated, the long thread with which the lower end of the esophagus was tied is pulled out through the wound in the neck. By traction on this thread the esophagus is again evaginated and drawn out through the neck after the staff has been released

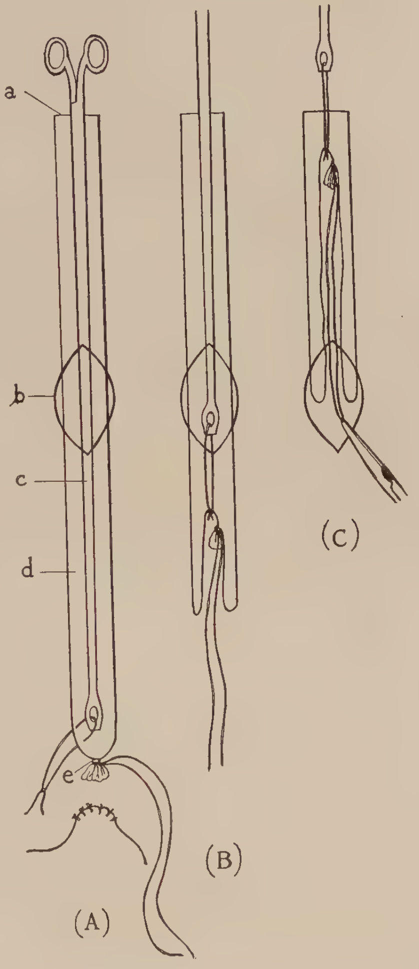


Fig. 18.—Diagram of Ach's Method of Extraction of Esophagus. A—a, mouth; b, incision in neck; c, thin steel rod introduced into d, esophagus, which is tied at e. B—Rod is drawn up and invagination begun. C—Invagination completed. The string with which the lower end of the esophagus had been tied has been drawn out through the cervical wound; the ring of the steel rod is now outside the mouth and can be released by cutting the string that passes through it.

by cutting the thread that passes through its ring, in front of the patient's mouth. The procedure is represented schematically in Figure 18.

Dangers and Difficulties.—Operations for resection of the esophagus are often attended by collapse due to the magnitude of the operation or to vagus reflex. Infection has been one of the greatest dangers. Its chief source has been from the esophagus and from the stomach either at the time of the operation or later, through leakage from sutures. This danger can be eliminated by adhering to my method of operating. Another source of infection may come from the lungs, if they were injured at the operation, in which case the danger of pneumothorax is superadded to that of infection. Care in handling the lungs and in separating adhesions eliminates that danger. Pneumothorax has been repeatedly assigned as a cause of death. It may arise either through leaving behind some air in the pleural cavity before closing, or the air may gain access from without after incomplete closure, or it may, through an injury of the lung, pass from that organ into the pleural cavity. The importance of the first of these causes of pneumothorax has doubtless been exaggerated. The amount of air remaining in the pleural cavity, after the lungs have been thoroughly distended on closing the thorax, is not apt to interfere very much with the function of the lung and will probably soon be absorbed. Of much more importance is the open pneumothorax, which is caused by a communication of the pleural cavity with the air outside of the chest or with the lung, as the constant admission of air causes a collapse of the lung and the danger of infection is superadded. Pneumonia has been the cause of death in a number of cases, and empyema in others.

The difficulty of the operation has been considerably lessened by my mode of access.

E. ESOPHAGOPLASTY

In cases of impassable and inoperable stricture of the esophagus the desire to construct a new extrathoracic communication between the cervical part of the esophagus and the stomach has given rise to a variety of plans for esophagoplasty. The reconstruction of the esophagus would, of course, also be desirable after resection of the esophagus. The material for forming an esophagus may be either skin or a portion of the gastro-intestinal tract, or both. Thus, a skin tube extending from the esophagus to the gastric fistula may be constructed, the epidermis forming the inner lining of the tube. The outer raw surface is covered by a plastic from the skin of the chest (Bircher).

The upper part of the jejunum may be used (Roux). A sufficiently long piece of jejunum is resected but left in connection with the mesentery. The ends of the jejunum which remain behind are united end to end. Of the resected portion, 4 or 5 arteries at the upper end are tied and divided in order to mobilize this end sufficiently to pull it upward. Care must be taken not to injure the arcades and the vasa recta arising from these, as the circulation of the oral end depends upon these anastomoses, after their arteries have been divided. The aboral end of the resected portion is implanted into the stomach. The oral end is brought out of the abdominal wound, pushed through a subcutaneous tunnel extending from the abdominal wound to the end of the esophagus, and united with it by suture.

Instead of the jejunum, the use of the transverse colon has been attempted (Kelling). A number of variations of these methods have also been proposed, for instance, the formation of an esophagus partly of intestine and partly of skin (Lexer, Frangenheim).

A new esophagus may be made of material taken from the stomach. Hirsch proposed utilizing a portion of the anterior wall of the stomach. A much better method is that of Jianu, who uses the greater curvature of the stomach in almost its whole length to make an esophagus. The oral end of this tube remains attached to the stomach, the aboral end being brought up through a subcutaneous tunnel, as in the case of Roux's method. This method is scarcely feasible if a gastrostomy according to the usual methods has already been done. If, therefore, a Jianu esophagus is contemplated, it should be constructed when the abdomen is opened for the purpose of doing the preliminary gastrostomy, provided that the case proves to be a favorable one for resection of the esophagus.

It has also been proposed to employ intrathoracically, instead of antethoracically, the various methods of utilizing the gastro-intestinal tract for restoring the esophagus.

OPERATIONS ON THE PLEURA

Anatomical Points on the Surgery of the Pleura and Lung.—The pleural cavities are sacs invaginated into themselves from their mesial sides by the lungs. The visceral pleura is firmly attached to the lung, the parietal pleura more loosely to the endothoracic fascia which it covers. According to location, the parts of the parietal pleura are named respectively sternocostal, diaphragmatic, mediastinal, and pericardial pleura. The spaces where these different divisions of the pleura meet, forming corners or angles, are called sinuses. Thus there are the mediastinodiaphragmatic sinus, the posterior costomediastinal sinus, the anterior costomediastinal sinus, and the costodiaphragmatic sinus. Of these the 2 last-named are not completely occupied by the lungs even at inspiration. Their relation to the chest wall is of considerable clinical importance.

The folds of reduplication of the pleura will be best understood by referring to Figure 19. The relations of the margins of the lungs and of the separate lobes to the chest wall are also represented there. It will be seen that both at the upper and the lower end of the sternum there is a roughly triangular field where its posterior surface is not covered by pleura. The anterior folds of the pleura are not always exactly at the lines shown in the diagram; they may be displaced to either side. The cardiac incisure of the lung is also seen. The lower border of the lung is seen to be at a higher level than the lower border of the pleura. The latter corresponds about to the lower border of the seventh rib in the mammillary line; in the axillary line it corresponds to the ninth rib, and farther back to the tenth intercostal space. Posteriorly it runs about horizontally to the spinal column, which it reaches at a level corresponding to the twelfth rib.

The mediastinal structures are bounded on the right and left by the mediastinal pleura. The right mediastinal pleura is in relation with the superior vena cava, the right phrenic nerve, the innominate artery, the trachea just above the bifurcation, the azygos vein, and the right sympathetic nerve.

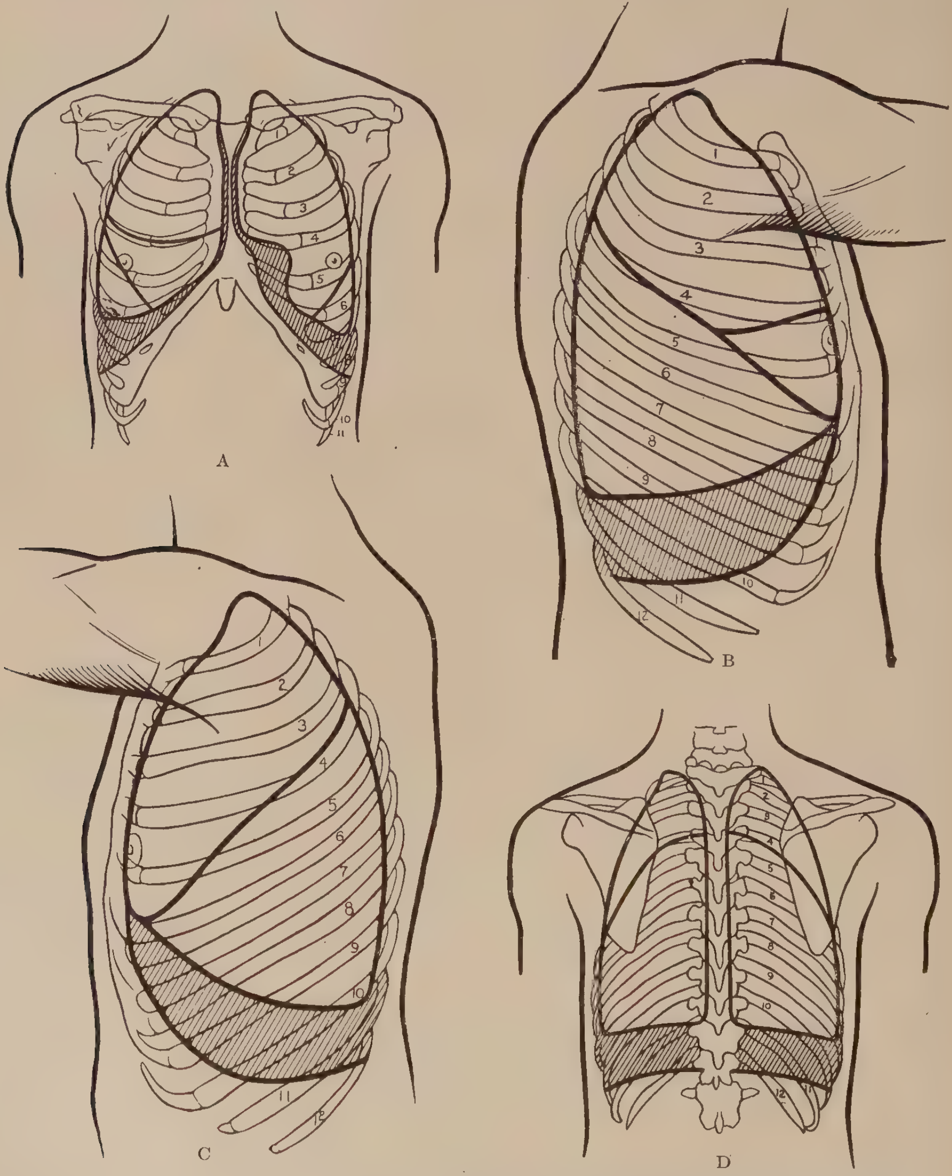


Fig. 19.—Diagram of the Folds of Reduplication of the Pleura; Projection of the Margins of the Lungs and of Their Separate Lobes.

The left mediastinal pleura is in relation with the thoracic aorta, the left sympathetic nerve, the hemiazygos vein, and the left subclavian artery. Both pleuræ may or may not touch the esophagus below the arch of the aorta.

That portion of the lung at which the bronchus and the great vessels enter it is called the hilus. Its position corresponds in height to the third intercostal space and the fourth costal cartilage in front, and to the fifth and sixth dorsal vertebræ posteriorly. In the root of the lung the artery is above, the vein below, and the bronchus in the middle, but more posterior.

A. PARACENTESIS

Indications.—Until rather recently the indication for paracentesis of the chest, the procedure of drawing off fluid from the thoracic cavity, was stated as being confined to cases where the pressure of the fluid interfered seriously with the action of the lungs or the heart, thereby endangering life, or where the effusion had remained stationary for a long time, about 2 or 3 months. The mere fact that a serous pleuritic exudate had been discovered was not considered an indication for its removal. At present, however, the tide of opinion is changing. A pleuritic exudate of long duration is not to be regarded as harmless, inasmuch as a deposit of fibrin may in the meantime cause a thickening of the pleura and may establish pleuritic adhesions, which would ultimately interfere with the expansibility of the lung. Compressed lung tissue may be replaced by callous material, resulting in the production of bronchiectasis. The presence of a fair-sized exudate is in itself considered an indication for its removal, especially since we have learned that air may be allowed to enter, as the fluid is withdrawn, and that, in employing this method, described below, every drop of the exudate can be removed.

The only exception to the rule is in cases of exudates of tuberculous origin, as these are believed to possess bactericidal attributes. The immobilization and compression of the lung, moreover, which they produce are of advantage to the patient, inasmuch as the cure of tuberculous foci in the lungs is thereby favored in a manner similar to that of intrapleural injection of nitrogen according to Forlanini, Murphy, and Brauer (see Tuberculosis of the Lung, page 545). But even here the fluid may be completely withdrawn and the collapse of the lung maintained by nitrogen injections.

Instruments Used.—A small-sized trocar may be used, over the end of which a rubber finger cot is slipped, the tip of which is cut off. This finger cot, by its collapse, forms a valve preventing the entrance of air. Or we may use a trocar that has a lateral outlet over which a long rubber tube is slipped, the end of the tube being submerged under an antiseptic fluid. The neatest instrument is Potain's apparatus in which the aspirating needle is connected by means of a rubber tube with a bottle from which the air has been exhausted. For the newer method of allowing air to enter the pleural cavity a trocar or a large caliber aspirating needle is all that is necessary.

Technic.—WITHOUT ADMISSION OF AIR.—The time-honored method of aspirating with careful avoidance of permitting air to enter is as follows: The posterior axillary or the scapular line is selected, and a puncture is made in the fifth, sixth, or seventh intercostal space. The skin is first prepared antiseptically, and the patient preferably sits up, being well supported. The instrument is introduced at the upper edge of a rib to avoid injuring the intercostal vessels. The fluid is allowed to flow out slowly, and, when about 1/2 or 3/4 of the exudate has been evacuated, the aspiration is stopped. If the patient manifests dyspnea, severe cough, marked stinging pain, or great weakness, the tapping is interrupted. The puncture is closed with collodion or by a small dressing.

WITH ADMISSION OF AIR.—Aspiration with the admission of air into the pleural cavity has a number of advantages over the method just described. The symptoms coincident with sudden removal of the fluid, such as great weakness, dyspnea, severe cough, and marked stinging pain, are avoided. Those symptoms appear to be due in part to the rather sudden establishment of negative pressure on the surface of the lung. The admission of air does away with this negative pressure. Furthermore, the direct irritation of the lung by the needle coincident with the expansion of the lung, as the fluid is withdrawn, is avoided; for the entrance of air allows the lung to recede from the needle. The most important advantage, however, is that all the fluid can be withdrawn. The tapping is continued until the last drop has run out. One of the agreeable features of this method is the fact that the presence of pneumothorax enables us to obtain very much clearer X-ray pictures of the lung than could be made before. A very welcome advantage is the simplicity of the apparatus, as nothing but a trocar is needed. It was thought at first that it would be necessary to measure exactly the volume of air that goes in, for fear that more air might enter than fluid escape. This would require more or less complicated apparatus; but experience has shown that it is unnecessary, as the exudate is under positive pressure. It was also thought at first that the air entering the pleura had to be sterilized; but the fear of air infection of the pleura is just as groundless as the fear of air infection of the peritoneum proved to be years ago.

The method is as follows: The patient is laid horizontally across 2 beds, so that the seat of the operation is in the space between the beds. A trocar is introduced and the patient turned so that the trocar is at the lowest point of the exudate. The serum will at first flow in a continuous stream; then, as the pressure from within diminishes, the stream will begin to halt on inspiration, until, during an inspiration, some air finds entrance, after which the flow again improves. This continues until there is no fluid left in the pleural cavity, when the trocar is removed and the opening closed with cotton and collodion or with sterile adhesive plaster. During the procedure the patient experiences no discomfort; there is no tendency to cough and no dyspnea. The air is absorbed in a few days.

Dangers.—The dangers connected with the introduction of a needle or trocar into the pleural cavity, which, however, can be readily avoided, are injury to the lungs, the heart, an aortic aneurysm, an intercostal vessel, puncture through the diaphragm into an abdominal organ, or the rapid formation of a pneumothorax.

B. OPERATIONS FOR EMPYEMA

Whenever a probatory puncture has revealed the presence of pus or turbid serum in the pleural cavity, its removal by operation is indicated. This may be done in various ways.

1. Puncture with Subsequent Drainage

Indications.—This procedure, being much less certain in its results than resection of a rib, is indicated only in patients too weak to stand the thoracotomy or in those very favorable cases of pneumococcus empyema of young children.

Technic.—It is performed by making a small skin incision, 1 to 2 cm. (½ to ¾ in.) in length, under local anesthesia, in the posterior axillary or scapular line over the seventh or eighth intercostal space. A trocar about the thickness of a finger is thrust into the pleural cavity, and a large drainage tube is introduced through the cannula, which is then withdrawn, while the drainage tube remains. A small sterile dressing is applied. After the pus has flowed out, a long tube, the end of which is submerged under an antiseptic fluid in a bottle, is attached to the drainage tube. If the flow of pus is interrupted by masses of fibrin, an irrigation with saline solution is made. When the patient is able to be out of bed he carries the bottle in a pocket. Strictest asepsis is necessary throughout. In favorable cases healing takes place in from 1 to 3 months.

2. Intercostal Thoracotomy

This operation, which is only slightly simpler than resection of a rib and less certain in its results, has been almost entirely discarded in favor of the latter procedure.

3. Resection of Ribs

Instruments.—The instruments used are a slightly curved and a strongly curved raspatory, a curved periosteum elevator, rib shears, a large sized aspirating syringe with a large caliber long needle, and instruments for the soft parts.

Anesthesia.—In adults the operation can be very well performed under local anesthesia; in cases of children general anesthesia is usually preferred, but the operation is also feasible under local anesthesia. A ½ to 1 per cent. solution of novocain with suprarenin is employed. The intercostal nerves are blocked from 2 or 3 points at the lower border of the rib to be resected, and the periosteum under the deep surface of the rib is infiltrated to the desired extent. It may be necessary to use a curved needle for this purpose. Then injections at the upper border and superficial surface of the rib are made, after which the soft parts in the periphery of the field of operation are infiltrated. Lastly, the line of incision is anesthetized. If several ribs are to be resected, the method is changed accordingly.

Technic of Operation.—A preliminary morphin injection is given. The patient is placed in the prone position with the affected side slightly lower than the sound side, so that the sound lung may not be impeded in its function. Over the eighth or ninth rib, in the posterior axillary or scapular line, an incision, 5 to 6 cm. (2 to 2½ in.) in length, is made down to the rib. The periosteum is divided in a line parallel to the borders of the rib and midway between them and is pushed with a periosteum scraper upward and downward. The upper and lower borders of the rib are then carefully stripped of the periosteum, taking heed that the latter is not perforated by rough treatment. The periosteum covering the deep layer of the rib is then readily stripped off by interposing a curved periosteal elevator (Fig. 20). The exposed piece of rib is now removed with rib shears. The periosteum with the underlying pleura is incised and the pus allowed to flow off slowly. Masses of fibrin appearing at the opening are removed, and finally a finger is introduced to dislodge any further pieces of fibrin that may have remained behind. After the greater portion of the pus has flowed out, the remainder can best be poured out by turning the patient so that the wound is at the bottom of the cavity. If the patient has coughed out any pus previous to the operation, so that a communication between the lung and the pleural cavity must be assumed to exist, irrigation of the pleural cavity is absolutely contra-indicated. In the absence of such communication, flushing of the pleural cavity can do no harm; in fact, a thorough cleansing at the time of the operation materially lessens the subsequent discharge and simplifies the after-treatment. Two thick drains are inserted, their inner ends protruding only a short distance beyond the pleura. Large safety-pins are inserted to prevent the tubes from slipping

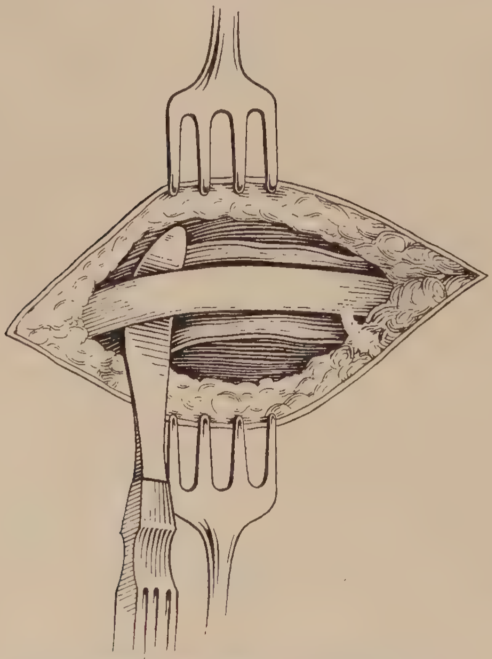


Fig. 20.—Stripping the Periosteum from the Posterior Surface of the Rib.

in. A voluminous dressing is applied firmly to prevent the aspiration of air into the pleural cavity. If the gauze does not suffice to accomplish this after it has become moist, an impermeable tissue may be placed on the wound.

Expansion of the lung is favored by forcible blowing exercises. Irrigations of the cavity are given only for special reasons, such as increase in the amount of discharge, ichorous discharge, rise of temperature, etc. In that case saline solution is employed, or permanganate of potash, acetate of aluminum, nitrate of silver, etc., may be used instead. The drains are removed as soon as the discharge ceases. If the closure of the cavity is delayed, the sinus may be hermetically sealed by a sheet of rubber perforated by a thick drainage tube. This sheet is fastened directly to the skin, and suction is applied to the drainage tube by one of various methods. As in thoracocentesis for pleuritic exudates, a Potain bottle may be used. Perthes' apparatus connected with a water pump (Fig. 21) is constructed somewhat on the same principle, but the partial vacuum in the flask, instead of being produced by a piston pump, is created through the action of the flow of water. The flask also differs from the Potain in having a third opening at the top, which connects with a manometer to record the pressure in the chest, and a fourth opening below, controlled by a stopcock, to permit the escape of the aspirated secretions. In Stork's flasks suction is produced by water flowing from one bottle into another situated at a lower level. Bier's hyperemia cups have also been used. Attention to proper hygienic and dietetic treatment is important. (See also Aspiration and Aspirating Devices in Surgery, Vol. I, Chap. VII.)

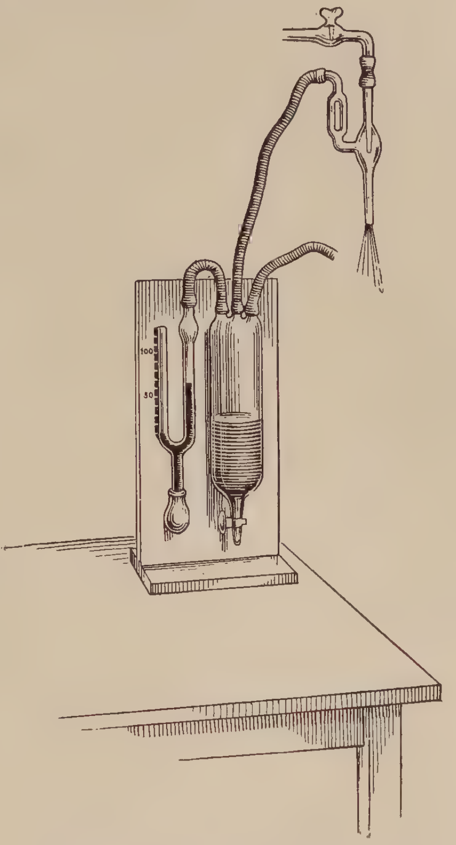


Fig. 21.—Perthes' Suction Apparatus. Flow of water causes partial vacuum in flask.

4. Estlander's Operation

Indications.—If an empyema fails to heal after months and the delay is not due to a removable cause, such as retention or superadded infection, the reason is to be found in a change that has taken place in the tissues adjoining the lung, which renders the expansion of the lung and the restoration of its contact with the thoracic wall impossible. This change consists in the formation of thick callous layers on the visceral or parietal pleura, or both. Such cases usually require a plastic operation to close the cavity, which consists in mobilizing either the chest wall or the lung.

Technic.—Estlander's operation for achieving this object consists in a more or less extensive resection of ribs. The size and extent of the cavity are ascertained by probing and by the radiographic picture of the cavity after injecting a bismuth mixture. Over the whole extent of the cavity the ribs are resected subperiosteally, so that the cavity is then covered only by soft parts. The chest wall is thus caused to collapse and is brought in apposition with the lung. From an incision over 1 rib the rib above and the one below can also be resected, and even more. Flaps of various shapes may also be made to expose the ribs.

5. Schede's Thoracoplasty

In rare cases, where the shape of the cavity is more complex, the soft parts, after Estlander's operation, cannot be properly brought into apposition with the lung. In those a thoracoplasty according to Schede is performed, which consists in removing, not only the ribs, but also all the soft parts of the thoracic wall between the ribs and underneath them. Schede also recommended making the mobilization of the chest wall very extensive. The incision starts from the upper part of the back, between the spinal column and the scapula, and descends to the lower border of the pleura, then curves forward and ascends again in the anterior axillary line, terminating under the pectoralis major muscle. The soft parts of this large flap are prepared upward, the scapula being raised in conjunction with it, and all the ribs from the second down are resected subperiosteally in their entire extent. Then, after opening the pleura, the intercostal muscles, together with the pleura, are cut away over the entire extent of the cavity, the thickened visceral pleura is scraped with a sharp spoon, and the skin flap is replaced, drainage tubes being introduced.

Depage recommended a similar incision, but, instead of the reflection of a skin flap, the ribs are divided in the course of the extensive incision and the thoracic wall is turned upward in its entire thickness. The ribs are then resected subperiosteally by incisions on the pleural surface as far as necessary, after which the flap is replaced. As compared with Schede's operation, this method is simpler and less bloody, because the separation of the skin flap from the thoracic wall is omitted. It presupposes, however, that the parietal pleura is not too unyielding to be able to adapt itself to the visceral pleura.

6. Sudeck's Method

Many surgeons, recognizing that an operation of the magnitude of Schede's is too formidable for a weakened patient to withstand, have divided it into 2 stages. Sudeck, in the first stage, resects the ninth rib and, through the same incision, the eighth. A hand's breadth higher up another incision is made, through which the sixth and seventh ribs are resected. These resections are done subperiosteally. The flap thus obtained is laid into the thoracic cavity and fastened there. As a rule, this flap attaches itself kindly to the lower part of the cavity, and the secretions from the upper part are led out above it. Drainage is secured by tamponing the entire cavity. Under this treatment the cavity shrinks rather rapidly. At a second operation the remaining upper part of the cavity is attacked by resecting the upper ribs according to the method of Schede and also resecting the lower half of the scapula. The musculature of the resected scapula and the skin flap are utilized for a plastic covering.

7. Decortication of the Lung

Instead of depressing the chest wall to meet the lungs by any of the preceding methods, Delorme and others have proceeded to obliterate old empyema cavities by removing the thickened, shrunken visceral pleura which compresses the lung and prevents it from expanding sufficiently to come in contact with the chest wall. The removal of the visceral pleura is called "decortication of the lung." The thick deposit on the lung is extensively incised and dissected off as far as seems necessary, after which, in most cases, the lung expands again. Unfortunately, the procedure is sometimes too bloody to be carried out as thoroughly as planned. To gain access to the lung, a temporary resection of the chest wall is made, usually in the shape of a flap similar to Depage's (see Schede's Thoracoplasty), which is again replaced after decortication is completed. The extent of the temporary resection varies, the most extensive being that proposed by Delorme himself, who reflects a flap consisting of the entire chest wall. Others have temporarily resected as much as appeared indicated in the particular case.

8. Combined Methods of Treating Old Empyemata

Ordinarily the surgeon will adapt the procedure to the particular case and will operate in some such way as the following: If there is a sinus leading into the pleura, 1 or 2 ribs are resected at that site to a sufficient extent to permit a thorough examination of the size of the cavity. If the sinus is so situated that proper exploration is impossible, or if no sinus exists, the lowest point of the cavity in the axillary line is located by physical examination, aspiration with a needle, and the X-ray, and 1 or 2 ribs are there resected, after which the cavity is explored. If the cavity proves to be small, an Estlander operation will suffice. If it is rather large, the incision is extended backward in a direction parallel to the ribs and then upward between the scapula and the spine as far as the examination of the cavity has shown it to extend. In this line the ribs and intercostal soft parts are divided. It is of advantage not merely to divide the ribs, but to resect 1 or 2 cm. (½ or ¾ in.) of each, as this will allow the liberated part of the chest wall to sink in subsequently. The intercostal vessels are tied as the soft parts are cut. In a similar manner, under guidance of the finger inside, the incision is carried forward and then upward as far as the cavity extends. The flap of chest wall is turned up and the pleura examined. If an incision through the thick visceral pleura shows that the lung is capable of expanding and that the thick deposits can be peeled off, this modification of Delorme's operation would suffice, especially as the chest wall would meet the lung to some extent, owing to the short rib resections made posteriorly. Should the lung not expand or decortication be impracticable, the ribs are resected from within, according to Depage (see Schede's Thoracoplasty), beginning with the lowest. If then the visceral pleura should prove to be too rigid to sink in, we must consider to what extent Schede's operation has to be performed.

9. INJECTION OF BISMUTH PASTE

If the pleural sinus does not lead into a cavity, or only into a very small one, from which there is little or no secretion, the injection of Beck's bismuth paste will sometimes effect its closure. The paste consists of 1 part of bismuth subnitrate and 2 parts of vaselin. This mixture is sterilized and injected while fluid and in a state of thorough mixture. A glass syringe may be used. The patient is placed in such position that the open end of the sinus is directed upward as the injection is made. When the sinus has been filled, its outlet is closed by placing the finger on it for a few minutes. During this time the bismuth, which is heavy, will settle to the bottom of the sinus. The fistulous opening is then closed by a small dressing.

C. OPERATIONS FOR BLEEDING FROM THE INTERCOSTAL AND INTERNAL MAMMARY ARTERIES

If hemorrhage from the intercostal and internal mammary arteries takes place during the course of an operation on the ribs or costal cartilages, they are tied at the site of the injury; if necessary, an additional part of the rib or an adjacent cartilage is resected to expose the vessel. In stab wounds or other injuries causing hemorrhage from an intercostal artery, the vessel is readily exposed by resection of the rib at the site of the injury. Its ligation without resection may be done in the following manner: The external intercostal muscle is divided close to its insertion at the lower border of the rib. Traction downward on the muscle will dislodge the nerve and vessel from the groove in the lower border of the rib, so that with great caution they can be surrounded by a blunt hook for ligating. The nerve is then isolated and the artery tied.

Hemorrhage from the internal mammary artery may be stopped by ligation of the vessel at a site of election. The vessel and its accompanying vein run a little laterally from the edge of the sternum and are separated from the pleura in the upper part only by a thin fascia, below also by the transverse thoracic muscle. Anteriorly the artery is in relation with the costal cartilages and the intercostal muscles. It may be tied in any of the intercostal spaces; the best access is to be had where the sternum is narrowest, preferably, therefore, in the second intercostal space. The incision starts at the middle of the sternum and extends from there outward between the costal cartilages. After division of the skin, fascia, and pectoralis major muscle, the very thin fascia of the external intercostal muscle, whose fibers descend toward the median line, presents. Under this lies the internal intercostal muscle. This muscle is divided together with the well-defined fascia at its deep surface, and the artery is seen about ½ to 1 cm. (¼ to ½ in.) from the border of the sternum, its course being from above downward. The vein lies on its mesial side. In the lower intercostal spaces the vessel is slightly further away from the sternum, 1½ to 2 cm. (½ to ¾ in.), and lies on the transverse thoracic muscle (triangularis sterni).

D. OPERATIONS FOR NEW GROWTHS OF THE RIBS

If a new growth affecting 1 or more ribs does not involve the pleura, it is removed by an extrapleural operation. As a rule, however, the pleura is involved together with the ribs and the intercostal muscles, necessitating the removal of portions of the entire thickness of the chest wall. At the present time we prefer to do these operations under intratracheal insufflation or differential pressure according to any of the methods mentioned under General Remarks on Intrathoracic Operations (page 506). The operation, however, has been done repeatedly without these aids, before they were available. In those cases, despite the collapse of the lung, the disturbance of respiration was sometimes surprisingly small. In a case, published by me in 1906, where I resected a very large tumor of the thoracic wall involving 4 ribs, the respiration remained undisturbed throughout the operation. Sauerbruch's chamber was then known but not available. In such cases the presence of adhesions here and there doubtless explains the absence of interference with the respiration.

If the operation is performed without intratracheal insufflation or differential pressure, the air should be allowed to gain access rather slowly. At the time when the pleura is opened the patient should not be too deeply under the influence of the anesthetic. The lung, if not already adherent, should be provisionally fastened to the chest wall at some part. If possible, however, preparation for the use of insufflation or differential pressure should be made, so that the surgeon will not be hampered in his attempt at radical removal of the new growth.

First one seeks to determine from what ribs the tumor takes its origin, for sometimes tumors of considerable size have a comparatively small base. The X-ray, as a rule, is of assistance. If the skin is entirely free and uninvolved, a long incision parallel to the course of the ribs will usually answer. In some instances a flap with its base directed toward the spine affords better exposure.

Often the skin has to be sacrificed with the tumor. After the extrathoracic portion of the incision around the tumor has been completed, the pleura is opened under intratracheal insufflation or differential pressure in an intercostal space. From this opening the ribs are cut with rib shears a sufficient distance beyond the limits of the affected area. Preliminary ligation of the intercostal vessels is unnecessary; they are compressed when divided and tied after the tumor has been removed. If a portion of the lung is involved, it is resected together with the affected chest wall, and in case the operation is done without differential pressure, the lung is first attached to the parietal pleura at some distance from the seat of the new growth in the lung. With the use of insufflation or differential pressure, this is not necessary; but the wound in the lung is sutured. When the resection is completed, the lung is made to expand so as to plug the opening in the thoracic wall. The skin is closed by mobilizing it from the neighborhood, or a flap from the abdomen or from the other side of the chest is taken and sutured over the defect, the subcutaneous tissue being sutured to the margins of the defect in the chest wall and skin to skin. Sometimes the breast from the opposite side is transplanted on the defect.

If the subscapular portion of the chest has to be resected, the scapula must first be raised off the chest. This may be done by making a T-shaped skin incision, the stem of the T corresponding to the mesial edge of the scapula. The trapezius and the latissimus dorsi are exposed, the fascia between them is incised, and the incision is extended upward into the trapezius and downward into the latissimus dorsi. Then the rhomboideus major is divided about 1 cm. (½ in.) from the edge of the scapula; if necessary, also the rhomboideus minor; and the scapula is turned outward by forcibly lifting up its mesial edge. After the operation on the chest wall is completed, the scapula is replaced and the muscles are reunited by suture.

E. RESECTION FOR TUBERCULOSIS OF THE RIBS

Tuberculosis of the ribs rarely involves any part of the pleura other than its external surface. If the process is in an early stage, where a small abscess with a well-defined wall communicates with the diseased rib, the abscess and the affected part of the rib can be removed in one piece the same as a tumor would be. Healing by primary union can then be expected.

In protracted cases, however, particularly those which have already opened externally, there may be very extensive and complicated sinuses. These require thorough exposure. The sinuses may have worked their way beneath a number of ribs between them and the pleura, so that in following up their course it may be necessary to resect several ribs before the primary focus is reached. If all sinuses are laid bare and scraped, even these cases will result in a complete cure, although the healing process may be protracted.

Tuberculous disease of the costal cartilages often requires the total removal of the cartilages and of a portion of the sternum.

OPERATIONS ON THE LUNGS

A. SUBCUTANEOUS INJURIES OF THE LUNG

The patient should be placed on the injured side. This position will not only permit the uninjured lung to perform its function more easily, but the pressure on the diseased side will also help to diminish the bleeding from the lung. The usual consequence of an injury to the lung is hemothorax and pneumothorax, both of which may be of greater or less significance.

Indications.—If the bleeding from the lung is considered to be moderate, it may be disregarded, as the blood will be reabsorbed if it remains sterile. If it becomes infected, an empyema will result. If the hemorrhage is severe, the thorax must be opened to secure the wound in the lung (see below). The resulting pneumothorax will vary in extent and significance according to the character of the wound in the lung. If the tear involves only the alveoli, bronchioles, and smallest bronchial tubes, these will be closed by blood-clots, and the air in the chest will be absorbed within a short time. If, however, a larger bronchus is torn, a spontaneous closure cannot be expected, and the wound must be sutured. In case the subcutaneous connective tissue communicates with the pleura, as in fracture of the ribs, an emphysema of the skin will result over the site of the injured pleura and may extend over the whole body. In the absence of such communication, the pneumothorax is confined. It may constantly increase, owing to a valve-like condition of the wound which permits the entrance of air into the pleura but prevents its escape. This condition is called valvular pneumothorax. The dyspnea caused by it may be extreme, and marked cyanosis of the face may appear. The pulse at first is normal but later becomes frequent. The patient is often in urgent need of relief by suture of the wound or by aspiration (see below and under Treatment of Pneumothorax). When a subcutaneous emphysema arises, the patient does not suffer to so great an extent, as the intrathoracic pressure is relieved by the escape of the air under the skin.

From a practical standpoint it is advisable not to be in too great haste to draw out the blood and air from the pleural cavity. Aspiration to remove these would imply the production of a negative pressure on the surface of the lung and its torn vessels and bronchioles, tending to keep them open, or to reopen them if imperfectly closed. It should, therefore, be deferred until we have reason to believe that the wound is closed. Le Conte even recommends the production of a pneumothorax in cases of marked hemorrhage by opening the chest and inserting a drainage tube. It certainly seems rational to expect that a wound in the lung will have a better chance of becoming sealed by a blood-clot if the lung is put out of function than if the wound is in constant motion.

In cases of severe hemorrhage and increasing pneumothorax, or a less severe but persistent or recurring hemorrhage, thoracotomy and suture of the lung are indicated. If, in subcutaneous rupture of the lung, the site of injury cannot be determined, it is best to enter at the lateral and posterior aspect, as from there the lung can be best drawn forward out of the costovertebral angle. This can be done without recourse to differential pressure or intratracheal insufflation, but the artificial inflation of the lung will render the procedure considerably easier. In a collapsed lung, even a fairly large tear may escape detection. When, however, the lung is inflated, frothy blood will appear at the wound and render its recognition easy. The patient will also recover more readily if, on closing the chest, the lung is inflated and the pneumothorax thus disposed of.

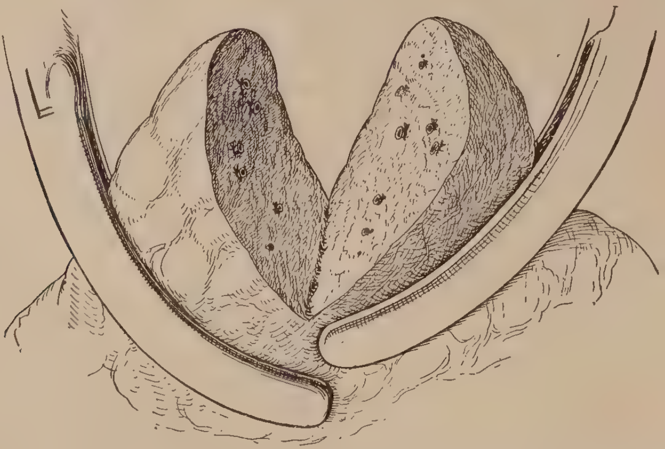


Fig. 22.—Application of Gently Compressing Clamps, Like Doyen's Intestinal Clamps, to the Wound of the Lung; Ligation of the Vessels and Bronchial Tubes.

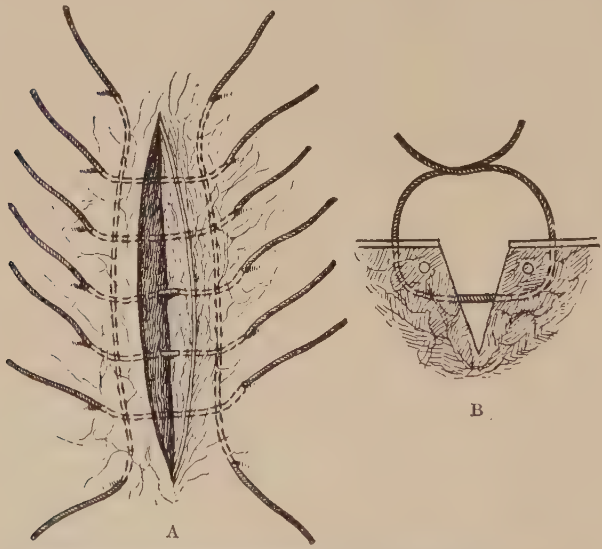


Fig. 23.—Lung Suture with the Aid of Supporting Threads. A—View of the surface; supporting threads run parallel to the incision, one on each side of it. B—Sectional view; supporting threads, one on each side, represented as minute circles under the edges of the incision.

Technic.—The method of procedure is as follows: The patient is laid on the sound side, a pillow being placed under the chest. An intercostal incision of ample dimension is made at the most probable site of the injury. The collected blood will be forced out through the incision. The lung is distended fairly well in order to show the site of the injury by the appearance of bloody foam. When the wound has been located, the lung is allowed to collapse to a considerable degree, as it is easier to suture it in that condition. The hemorrhage is best controlled, temporarily, by clamping the lung on each side of the wound by a gently compressing instrument like Doyen's intestinal clamp (Fig. 22). If the wound is ragged, it is now cut smooth, so that the vessels and bronchial tubes may be recognized and tied. The clamps are then removed. If now the bleeding has ceased, a suture like Lembert's for the intestine suffices; if the wound continues to bleed, sutures entering deep into the lung tissue are to be preferred. If the parts have to be approximated under tension, the use of supporting threads is of value. One of these is introduced on each side of the wound, parallel to it, and the sutures that bring the edges together are passed outside and underneath these threads. The supporting threads protect the lung tissue from being cut through by the sutures (Fig. 23, A, B). For small wounds that can be closed without tension, fine silk may be used; but if heavier material is required, catgut is to be preferred. The lung is then again distended. The escape of some air from the stitch canals is of no importance. The chest is closed by bringing the 2 ribs in apposition and suturing the soft parts, as described under General Remarks on Intrathoracic Operations (page 508).

If the operation has to be performed through one of the upper intercostal spaces, the scapula must be raised from the chest, together with its musculature, as in thoracoplasty.

B. OPEN WOUNDS OF THE PLEURA AND LUNG, INCLUDING GUNSHOT WOUNDS

Gaping wounds of the thorax, such as those caused by swords, daggers, burst shells, or by impaling, should be considered as infected. They are cleansed of fragments of clothing or other foreign material, and the hemorrhage from the thoracic wall is stopped. If bleeding from the lung now appears, there is a clear indication for operative interference. The wound of the thorax is enlarged, the bleeding part of the lung is drawn forward, and the blood vessels are ligated, or the hemorrhage is controlled by deep suture of the lung. Where suture is impossible, tamponing is resorted to. Drainage of the pleural cavity at the most dependent portion is usually employed owing to the assumption that the wound was infected, though closure without drainage is preferred by some. If the pulmonary wound is tamponed, the pleural cavity must be drained, unless it is possible to attach the torn portion of the lung to the chest wall, in which case drainage of the pleura is omitted. A dressing similar to that in operations for empyema closes the wound and prevents the entrance of air after it has become moist. Should infection of the pleura take place and result in empyema, it is treated like other empyemata.

Gunshot wounds of small caliber have been found through experience in recent wars to be sterile in almost all cases. They should not be probed, nor should they be opened for the purpose of cleansing or tamponing them. They are temporarily covered with a little gauze, and the skin around the opening is rendered aseptic, after which a permanent dressing is applied. Pneumothorax and hemothorax very rarely occur after these injuries, and if the bullet is still somewhere in the thorax, it is allowed to remain there.

C. PNEUMOTHORAX AND HEMOTHORAX

An explanation of the dangers coincident with the production of pneumothorax has already been given under General Remarks on Intrathoracic Operations (page 504). The pneumothorax produced in the course of operations on the pleura and the methods of avoiding or counteracting serious results due to this cause were discussed there.

Injuries of the lung, with or without fractures of the ribs, will cause the entrance of air and blood into the pleural cavity. Open wounds of the pleura will bring about the same result. Although these injuries are of serious significance, the pneumothorax and hemothorax which they produce are, nevertheless, generally treated expectantly, for in many cases the air and the blood are reabsorbed. If the hemothorax and pneumothorax are due to a wound in the thoracic wall, the bleeding is stopped and the wound is cleansed. It is closed by suture and drained, if necessary, or, if the ragged condition of the wound does not permit suturing it, access to the pleural cavity is shut off by a dressing. The patient should lie on the affected side, so as to compress it and to enable the healthy side fully to perform its function.

As regards the presence of air in the pleural cavity, we should bear in mind what was stated under Treatment of Subcutaneous Injuries of the Pleura and Lung (page 535) as to the beneficial influence of pneumothorax on bleeding from the lung. Only if pressure on the lung causes dyspnea, the air and blood should be removed by puncture and aspiration. Dyspnea will be promptly relieved by this procedure, and, if the wound in the lung is closed, there will be no recurrence. If the wound is still open, recurrence will take place and may require repeated aspiration or operation. If puncture fails to draw the blood, thoracotomy should be performed, preferably under insufflation or differential pressure. With the help of artificial inflation, the lung, if uninjured, will be promptly and completely distended. If a fairly large pulmonary wound exists, the expansion of the lung will not be complete. The employment of intratracheal insufflation or differential pressure enables us at once to recognize the presence of a wound and to discern whether it is insignificant or important. All wounds of moderate or large size should be sutured. The method is described under Treatment of Subcutaneous Injuries of the Lungs (page 536). If apparatus for insufflation or differential pressure is not available, we must remember that the element of greatest danger in pneumothorax is the to-and-fro motion of the mediastinum, the so-called mediastinal fluttering (see General Remarks on Intrathoracic Operations, page 505); therefore, the attachment of the lung to the parietes is to be resorted to, as this attachment gives support to the mediastinum. The lung is seized with the hand or forceps and is attached by a few sutures. As a temporary treatment, the patient should be made to lie on the affected side, not only for the reasons stated above, but also because in that position the mediastinum will tend to sag toward that side, and mediastinal fluttering will be reduced to some extent.

Bilateral pneumothorax requires immediate intervention by aspiration or, if the thorax is open, fixation of the lung to the chest wall.

D. ABSCESS OF THE LUNG

Abscess of the lung, when seen by the surgeon, is usually encountered in the form of a large, chronic, open abscess, that is, one that has perforated into a bronchus and has manifested itself by expectoration, from time to time, of large quantities of pus, the evacuation being followed by a temporary improvement in the physical signs. Spontaneous recovery from these large abscesses is rare and cannot be depended upon; hence their evacuation and drainage by surgical means are indicated.

The operation is preferably done under local anesthesia, as described under Resection of Ribs (page 527). The lung itself need not be anesthetized, as it is insensitive to pain. First of all, the seat of the abscess is accurately localized with the aid of X-ray pictures, its site being marked on the chest wall with nitrate of silver or by some other tracing; then the patient is laid on his healthy side with the head low, to favor emptying the abscess by expectoration. The lobe that contains the abscess is exposed by resection of as many ribs as may be necessary and sutured to the pleura. This suturing is preferably done before opening the pleura, the healthy portion of the lung in the vicinity of the abscess being fastened by carrying the needle deeply enough through the pleura to catch the lung. The back stitch is the safest (Fig. 24). As the parietal pleura tears easily, it is well to embody with it some other tissue in the stitch; or, if there is no other tissue at disposal, one may sew over a gauze pad. On the visceral side the stitch should embrace lung tissue. To avoid infection of the pleura, the opening of the chronic abscess is done at a second stage, usually about a week later, when adhesions at the line of suture have become firm enough. By that time the abscess will have filled up again; it is opened with a knife or cautery under guidance of an aspirating needle used to again

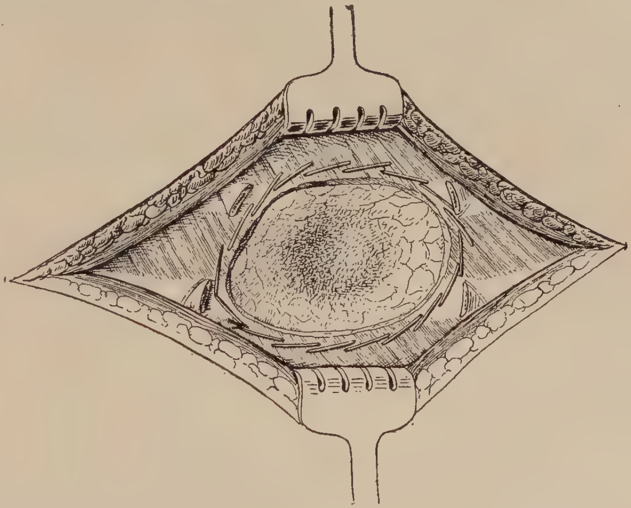


FIG. 24.—LUNG ATTACHED TO THORACIC WALL BY BACK STITCH.

localize the abscess. No irrigation is employed, as this would tend to spread infection to other parts of the lung, and the patient would also be in danger of drowning. The wound is tamponed with iodoform or other antiseptic gauze, or a drainage tube surrounded by gauze is used.

In acute abscesses, whether metapneumonic, embolic, or due to suppuration from foreign bodies, it is desirable to evacuate the pus as promptly as possible; therefore a one-stage operation may be more advisable. This requires that the back-stitch suture of the lung to the parietes be made thoroughly reliable. Adhesions, in acute abscess, are, as a rule, scarce and thin. It may be difficult in these cases to make sure, by inspection through the unopened pleura, whether the abscess presents at the place where the ribs have been resected. Under those circumstances it is better to narcotize lightly under intratracheal insufflation or differential pressure and to examine by palpation. The seat of the abscess is then definitely determined by the firmer consistency of the lung tissue. The operation is done in the same manner as for chronic abscess.

The subsequent course is much more favorable in acute than in chronic abscesses. The wall of the abscess soon becomes clean, and the surrounding tissue contracts, so that healing may be complete without fistula in from 6 to 8 weeks. Chronic abscesses take a much longer time to heal. The mortality ranges from 13 to 30 per cent., which is very favorable when compared with the results of medical treatment.

Old abscesses sometimes have firm walls, similar to those of old empyemata, and may require extensive resection of ribs or thickened pleura to obliterate them. A fistula of the lung may remain after the suppurative process itself has ceased. These sinuses are apt to be particularly obstinate, owing to cicatricial retraction of the surrounding tissues, which also tends to produce bronchiectasis. Resection of the ribs, loosening of the parietal pleura, and excision of the thickened portions of the pleura may be necessary to enable the sinus to close. Or the lung tissue itself may be freshened and sutured, a procedure which may require the mobilization of an entire lobe to render the suture feasible.

E. GANGRENE OF THE LUNG

The treatment of this condition is similar to that of abscess of the lung; the affection, however, is graver owing to the absorption of foul discharges from the gangrenous lung. The seat of the gangrene is localized by the X-ray, which shows a distinct shadow before putrefaction sets in; later, the picture will more closely resemble that of a cavity. The operation is preferably done in 2 stages, as in abscess of the lung. For opening the gangrenous area, a Paquelin cautery is usually preferred. A blunt instrument, such as a dressing forceps, may also be employed. When the cavity has been opened, the débris is removed with the finger, **care being taken, however, to avoid breaking down any more or less firm bands that stretch across, as these often contain blood-vessels.** The cavity is drained by gauze packing or by a cigarette drain, or a rubber tube surrounded by gauze may be introduced. The mortality averages about 34 per cent., which compares favorably with the mortality of 75 to 80 per cent. under medical treatment.

F. BRONCHIECTASIS

Indications.—Bronchiectasis is a suppurative process in the lung which differs from abscess in the manner of its distribution. Operative interference is indicated by the presence of large quantities of putrid sputum, the repeated occurrence of collateral aspiration pneumonias and hemorrhages, and serious impairment of health through septic absorption. Where the patient's complaints are of a less degree, we are not yet justified in recommending operation, considering that operative results are far from satisfactory.

Methods of Operation.—If there be a single cavity, the indication is to open and drain it as an abscess. But in the presence of multiple bronchiectases little would be achieved by incision. These are attacked indirectly by various methods. The production of artificial pneumothorax, as described under Tuberculosis of the Lungs (page 545), is one method. In many cases it will be impossible to resort to this method on account of extensive adhesions. If it can be carried out, the collapse of the lung will be accompanied by a diminution in the size of the bronchiectasis. In cases with extensive adhesions my operation of "interpleural pneumolysia" (page 548) would probably be indicated.

Another method is thoracoplasty, the more or less extensive resection of ribs, as for old empyema. It is indicated in cases where the bronchiectasis follows in the course of pleuritic thickening and subsequent contracture of portions of lung tissue. Early operation increases the chances of improvement. Luxembourg resected the first 7 ribs and divided the clavicle after a preliminary pneumothorax treatment. The result was very satisfactory.

Still another method is the artificial production of shrinkage of the lung tissue by ligation of the pulmonary artery. Animal experimentation has proved that connective-tissue contraction really does occur. In cases of bronchiectasis in man improvement has resulted, but thus far no cure by this or either of the preceding methods has been attained. The combination of ligation of the pulmonary artery and thoracoplasty appears to afford a better chance of improvement than either procedure alone. The ligation is performed first, the thoracoplasty a few weeks later, only those ribs being resected which overlie the affected lobe. In the case of the lower lobe, where the ligation of the pulmonary artery has been best studied, the incision is made in the fifth intercostal space, the arm being held upward and backward. The pleura should be divided carefully, as the lung is apt to be attached to it by adhesions, the presence of which can usually be made out through the unopened pleura, inasmuch as the to-and-fro motion of the lung does not take place. In the absence of adhesions it is not difficult to reach the root of the lower lobe, where the bronchus and the pulmonary artery and vein are found. The artery lies above, the vein below, the bronchus. The root of the lobe is best exposed by blunt dissection with gauze.

If one remembers the relative position of bronchus, artery, and vein, the vessel is readily located. Not infrequently the branch supplying the lobe divides high up, in which case its subdivisions are best tied separately. The lung is fully distended on closing the thorax.

G. ACTINOMYCOSIS OF THE LUNG

In cases characterized by the presence of external fistulæ, one can proceed from these and follow them up into the lung, dividing all the sinuses thoroughly, cleaning them out, and treating them with tincture of iodin or carbolic acid and alcohol. Iodid of potassium is administered as part of the treatment.

It is certain, however, that a complete extirpation of the affected tissues gives a much better guaranty of radical cure than the incision of sinuses, and if the process is sufficiently localized, one will scarcely hesitate to choose this method. But in extensive involvement of the lung, where radical resection (see Resection of the Lung) would be an operation of extraordinary magnitude, it will be necessary to weigh carefully the benefits to be derived from the one or the other method of procedure.

H. TUBERCULOSIS OF THE LUNGS

Removal of tuberculous foci from the apices has been done successfully a few times, but the prospects of cure by this means are not good except in incipient cases, when these foci are still isolated.

Resection of the Diseased Apex.—Of the surgical modes of attacking the tuberculous lung directly, the most rational is a resection of the whole diseased apex. Tuffier has developed a method of extrapleural procedure which in some instances has been followed by cure. An incision in the first intercostal space is made down to, but not through, the pleura. The ribs are spread, and the finger is introduced to strip off the parietal pleura. The finger does not enter the pleural cavity, but the stripping is done altogether outside of the parietal pleura. This procedure is not difficult in the anterior part of the thorax, but much more so at the vertebral column. When the affected part of the lung, with its parietal pleura, has been liberated, it is drawn forward and cut off, after it has been transfixed and tied off in 2 sections with stout catgut. The stump is then dropped back into the thoracic cavity and the wound closed. The remaining part of the lung expands and fills the gap. This method should be employed only in incipient tuberculosis; when a cavity exists, the process is, as a rule, already too diffuse to expect its radical removal by such interference.

Freund's Method.—Freund's method of procedure in tuberculosis by a chondrotomy of the first rib was designed to correct congenital shortness of the first costal cartilage, which produced narrowing of the upper thoracic aperture and hence constriction of the apex of the lung, conditions which predispose to tuberculosis of the apex. The operation is usually done on both sides. An incision along the lower border of the clavicle is made, the arm elevated as high as possible, and the perichondrium of the first costal cartilage split. A subperichondrial resection is done with the aid of a rongeur, the resection extending about as far out as the subclavian vein. A muscle flap is then implanted into the gap. The operation is not supposed to cure the tuberculosis but only to overcome the disposition and pave the way for a cure.

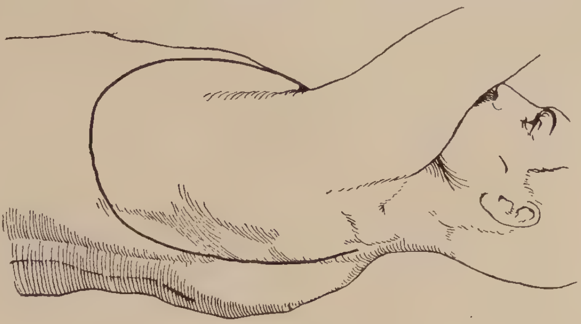


FIG. 25.—INCISION FOR FRIEDRICH'S THORACOPLASTY.

Friedrich's Method.—Other methods of treatment have for their object the collapse of the affected lung in order to give the tuberculous process a chance to undergo that shrinkage which appears to be necessary to bring the disease to a standstill. One way (Friedrich) of accomplishing this is by extensive resection of ribs on one side of the thorax. It is indicated only when the other lung is in fairly good condition. Under local anesthesia the ribs, from the second to the tenth, are laid bare through a large U-shaped incision going down on the back along the angles of the ribs and up in front at the costal cartilages (Fig. 25). The flap thus formed, which consists of the skin and all the muscles

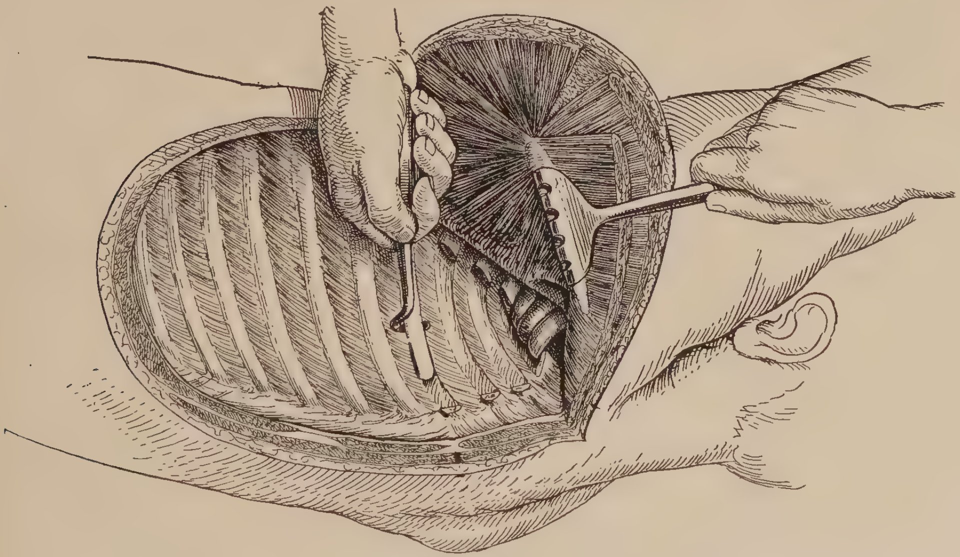


FIG. 26.—THORACOPLASTY; EXPOSURE OF CHEST WALL AND SUBPERIOSTEAL RESECTION OF RIBS.

covering the chest and includes the scapula with its muscles as well, is dissected up. The ribs are resected subperiosteally with the aid of Doyen's or Friedrich's blunt elevator (Figs. 26, 27). Either both ends of the ribs are cut, or they are divided merely in front at their junction with the cartilages, after which they are raised out of their periosteal beds and the posterior ends are twisted off. The large flap is then replaced and drained. To support the side which has been deprived of its bony wall, and to prevent oscillation of the collapsed lung and the mediastinum from side to side, the operated half of the thorax is firmly strapped with adhesive plaster or other straps to the opposite side. In order, however, to avoid interference with the respiratory action of the better lung, the straps are not anchored over the thorax of the non-operated side but to the shoulder and to the hip.

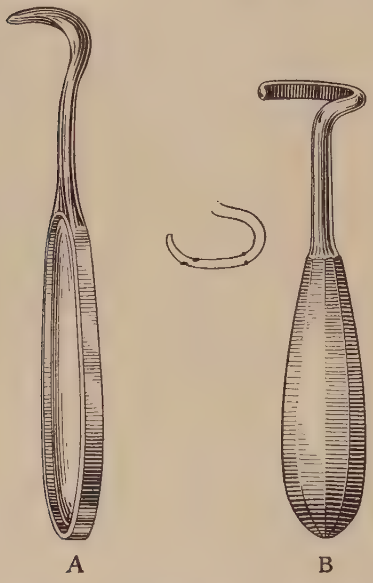


Fig. 27.—A—Friedrich's Blunt Periosteum Elevator. B—Doyen's Blunt Periosteum Elevator.

This operation is by no means free from danger. It is an operation of considerable magnitude for a very sick tuberculous patient to undergo. Nevertheless it is, as a rule, well borne at first. But after operation cardiac weakness is usually noted, probably due to deviation of the mediastinum with the heart and the great vessels to the non-operated side. The mediastinum will oscillate from side to side, as in open pneumothorax (see General Remarks on Intrathoracic Operations, page 505), being pressed toward the operated side on expiration and drawn toward the well side on inspiration. Furthermore, on expiration, only a part of the expired air finds its way out through the mouth or nose, some of it being forced into the collapsed lung. At the subsequent inspiration this air in the collapsed lung, which, of course, has not been oxygenated, is drawn back again, so that the exchange of gases is very much reduced. The patient shows great dyspnea and cyanosis, and the pulse is small and rapid. Expectoration is similarly impaired; in fact, it is often possible only if the operated side is supported. Hence the importance of giving it this support by strapping it to the opposite shoulder and hip, as above described. Many a patient dies in consequence of this respiratory insufficiency and secondary cardiac failure owing to the increased resistance in the pulmonary circulation. If the patient survives for 6 or 7 days, the organism adapts itself to the changed condition, and he improves.

Two-stage Thoracoplasty.—In order to avoid the dangers of this extensive operation, it has been modified and performed in 2 stages. First, the fifth to the eighth ribs are removed in the same manner as above described. After a few weeks the second stage is performed. This consists in a resection of the first to the fourth rib from an anterior and upper incision. The arm on the side of the operation is elevated as high as possible in order to expose the mesial end of the first rib beneath the clavicle. The incision runs along the clavicle from without inward and then turns downward about 1 or 2 cm. (½ in.) from the border of the sternum. This incision divides the origin of the pectoralis major muscle. The flap of skin and muscles is turned out, exposing the upper ribs in ⅔ of their extent. Now the second rib is resected subperiosteally as far as possible. This causes the lung to sink in somewhat and to recede from the lower border of the first rib. The periosteum of the first rib is cut along its lower anterior border, after which the rib is divided subperiosteally with a narrow rongeur which bites out a small furrow. To avoid injuring the subclavian vein, it is pushed up with a finger and held there. Then as much as possible of the mesial and lateral end of the first rib is removed. The third and fourth ribs are then resected, and the flap is returned to its former position, where it is sutured.

Another method (Wilms) consists in the resection of about 3 to 4 cm. (1¼ to 1¾ in.) or more of the first 8 ribs at their posterior ends and the removal of the costal cartilages of the same ribs. Straps of adhesive plaster are employed to assist in the compression of the lung.

Pneumothorax Method.—Still another ingenious method of causing the lung to collapse is the artificial production of pneumothorax by the injection of nitrogen, as recommended first by Forlanini, later by Murphy and Brauer. If one could be certain of causing collapse of the lung at the site of the disease, this method would surely be of the greatest value; but it is well known that in tuberculosis of the apex that part is, as a rule, bound down by adhesions which hold it, not only at the top, but also at its periphery. **The artificial pneumothorax, therefore, will cause a collapse of the healthy portion of the lung, but will have much less effect on the diseased part.** Nevertheless, the reports regarding this method are favorable. Hemoptysis has been stopped or materially lessened by it (compare Le Conte's method of inducing pneumothorax to control hemorrhage due to injury, under Treatment of Subcutaneous Injuries of the Lungs, page 535). Of course, the pneumothorax must be induced on the side from which the hemorrhage comes; otherwise the patient's condition will be rendered worse. It may not always be possible to ascertain from which side the hemorrhage originates. If the adhesions are few enough to permit the lung to collapse, the cavities in that lung will also collapse. The walls of these cavities will come closer together, and their contents will be forced out. In consequence, there will be at first an increase in the expectation, later a diminution.

As the collapsed lung plays no part in arterializing the blood, the right heart is obliged to increase its work in order to send enough blood to the other lung to obtain the necessary supply of oxygen. In pneumothorax of long standing, hypertrophy of the right heart has often been observed. The method is therefore contra-indicated, if severe circulatory disturbance is already present.

Nitrogen is used for injection into the pleura owing to its harmlessness and

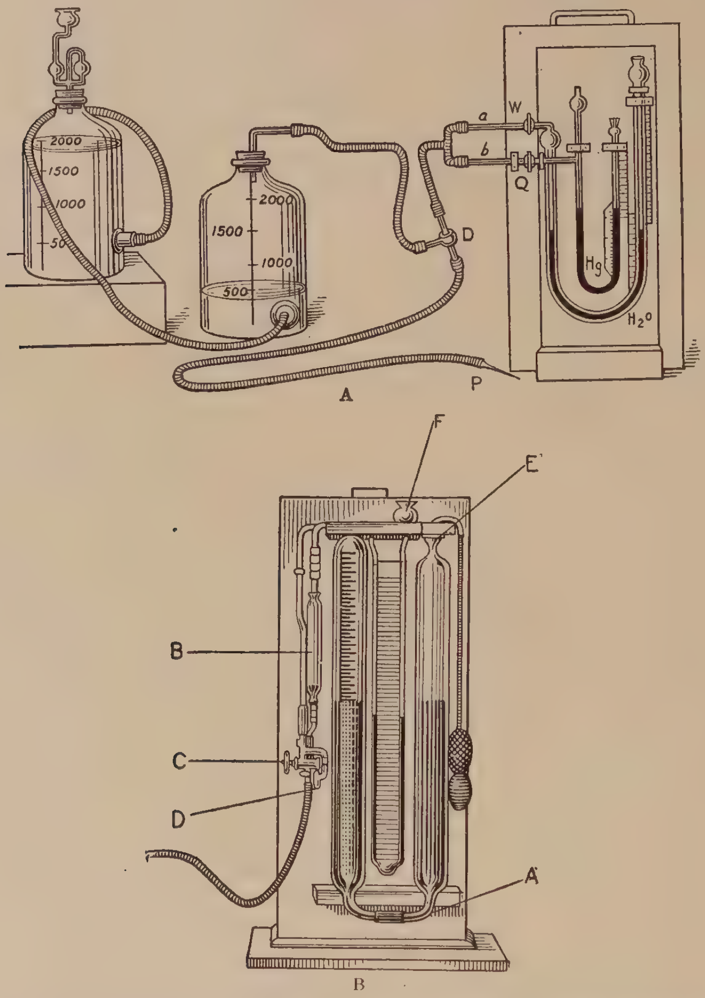


Fig. 28.—Apparatus for Producing Artificial Pneumothorax. A—Brauer's apparatus. P, puncture needle; D, stop-cock for manometer; a, tube connecting with W, water manometer; b, tube connecting with Q, mercury manometer. B—Knopf's apparatus. A, rubber hose connecting the two large glass tubes. B, tube for sterile gauze to filter gas. C, stop-cock; when turned in one direction it connects with tank or pleura; in other direction connects with manometer. D, stop-cock for connection with manometer while gas is flowing into pleura. E, stop-cock for connection with hand bulb. F, funnel for filling manometer tube.

because oxygen or air is absorbed too rapidly by the pleura to be of any service. Nitrogen is absorbed slowly, and the longer it remains, the less the pleura seems capable of absorbing it. The nitrogen is usually obtained from a tank. To inject it the following apparatus, a number of modifications of which also exist, serves to measure the quantity and control the pressure (Fig. 28 A). Two graduated bottles, each holding 2,000 c. c. (2 qt.), are connected by outlets near their bases. One of these containers is filled with bichlorid of mercury, 1 to 1000, and closed by a rubber stopper carrying a glass tube. This tube is connected with the nitrogen tank. As the nitrogen enters this bottle, the bichlorid is forced into the second bottle, which may or may not be closed at the top by a water valve. The first bottle, which is now filled with nitrogen, is disconnected from the tank, and a small trocar or needle is attached. The trocar or needle is introduced into the pleura, and the second bottle, which contains the bichlorid, is raised, so that this flows back again into the first bottle and forces the nitrogen into the pleural cavity. The force can be regulated by holding the second bottle higher or lower, or by the use of a blower connected with the neck of the second bottle, and the quantity injected is read off from the graduations on the bottle. A manometer interposed between the nitrogen bottle and the trocar indicates the pressure within the pleural cavity. Figure 28, B, represents Knopf's modification of the apparatus.

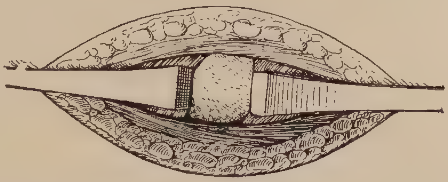


Fig. 29.—Exposure of the Pleura for the Establishment of Artificial Pneumothorax.

The site where the lung is least affected is chosen for injection. Sometimes, owing to adhesions, a new site has to be selected. The first injection is made either through a needle or a small incision, the latter being chosen to avoid injuring the lung. With the needle, injury to the lung can scarcely be avoided, and surely not if the lung is adherent at the site of puncture. We proceed as follows: After a preliminary administration of morphin, an incision 2½ to 3 cm. (1 to 1¼ in.) in length is made under local anesthesia down to the intercostal muscles. These may be either cut or separated bluntly. They are held apart with blunt hooks, and the pleura is exposed (Fig. 29). Through it one can see the lung move to and fro, if it is not attached. If the lung is not free at that site, the wound is closed again, and another attempt is later made elsewhere. If a suitable place, free from adhesions, has been found, the pleura is pierced with a blunt cannula, and the nitrogen is injected with the aid of the system of bottles above described. After the injection has been made, the wound is carefully sutured air-tight. If possible, the incision is made either at the side or front of the chest in the fifth to the seventh intercostal space to avoid the necessity of cutting the external thoracic muscles; the incision, however, may be made anywhere. The nitrogen should be warmed before it is introduced.

If a needle is used for the first injection, it should be introduced slowly through the intercostal muscles, until the thoracic fascia is felt with the point of the needle; it is then necessary to advance it only a short distance to enter the pleural cavity. Of course, there is always the risk of puncturing the lung and almost a certainty of doing so if there are adhesions at the site of the injection. Those who practice this method claim that a very slight injury to the lung does no harm. Opposed to this view, however, stands the fact that a relatively large number of deaths have occurred after this method, caused by air embolism. Furthermore, the accidents called pleura-reflex or pleura-epilepsy which have occurred after puncture were doubtlessly lighter grades of transitory air embolism. The danger of retrograde infection of the pleura through puncture of the lung also exists. After the first injection, the subsequent injections are always made with the needle.

Some use large quantities, one or two liters (quarts), repeating the injections at longer intervals, about every 6 weeks. Forlanini uses about 400 c. c. (13 oz.) at the first sitting, injecting every day or every other day, till the collapse is complete. Then the injection is repeated every week or 2, later every month or every 2 months. The pneumothorax is kept up for 1 or more years.

If both lungs are involved, the worse of the 2 is chosen for treatment, and it has been found that the other lung also improves, probably owing to the diminution in the absorption of septic material.

The method is valuable because it can be used even in advanced cases with cavities, cases that are not fit to undergo the other methods of surgical treatment of pulmonary tuberculosis.

Interpleural Pneumolysia.—Among well-advanced cases of tuberculosis of the lungs, in a large percentage there are such extensive adhesions that the pleural cavity is practically, if not completely, obliterated. The method of pneumothorax treatment described above is evidently not applicable in those cases, as the nitrogen cannot be introduced. Or, if only a small portion of the pleural cavity is free from adhesions, the collapse of the lung produced by the injection of nitrogen will be too slight to be of much if of any value. In many cases of pneumothorax treatment the X-ray pictures taken after the introduction of nitrogen reveal the fact that, while the lower part of the lung collapsed to a slight or fair degree, the upper portion remained entirely uninfluenced. The expected obliteration of cavities in the upper part, through collapse of the lung, therefore, could not ensue or at most only to a limited degree.

Recognizing these facts, I devised the operation of separating intrathoracically the adhesions that bind together the visceral and parietal pleura, the object of the procedure being to enable the lung to collapse. I have termed this procedure *interpleural pneumolysia* (from *lysis,* a loosening, which, in accordance with Greek usage, is changed to "lysia" when compounded with another word not a preposition). The modifier "interpleural" is employed to distinguish the method from that of separating the parietal pleura from the chest wall. Tuffier, for instance, in resecting the apex, separates that portion of the parietal pleura which covers the apex from the chest wall, but leaves the parietal pleura attached to the visceral pleura.

Anesthesia is conducted by intratracheal insufflation or under differential pressure by other methods in order to guard against the possible occurrence of respiratory accidents. An incision of ample dimension, about 15 cm. (6 in.), is made in the sixth or seventh intercostal space down to the pleura, and after all hemorrhage has been stopped the pleura is opened. The patient is now placed with the head low, so that, if in the course of the manipulation of the lung the contents of a cavity are expressed, they may run into the mouth and not into the opposite lung. The adhesions between the 2 layers of pleura are then separated. This is accomplished by introducing at first only the tip of a finger to separate the adhesions in the immediate vicinity of the incision, the ribs being held apart by retractors. The separation then proceeds further and further, until finally the whole hand is introduced into the chest in order to liberate the more distant parts of the lung. In the course of this procedure, bands of adhesions may be encountered that are so dense as to require division with the aid of scissors. When the separation of adhesions has been completed, the lung will collapse as much as the degree of its infiltration permits, and it is allowed to remain in this state of collapse. The pleural cavity is closed without drainage. The 2 ribs which have been spread apart are brought in apposition by pericostal sutures of silk or chromic gut (Fig. 9), the muscles are sutured with catgut, and the skin with silkworm-gut. Following this operation there is none of the pain that is often experienced after the injection of nitrogen in the pneumothorax treatment of tuberculosis described above. This absence of pain is due to the fact that, although the collapse of the lung is extreme, there is no tugging on the pleura as is often the case in the pneumothorax treatment, where the injected gas doubtless often causes sufficient pressure to stretch some of the adhesions, thus giving rise to pain.

If a cavity in the lung extends well to the pleura, the wall of this cavity may be injured in the process of separating adhesions. In that case the inspired air will gain access to the pleural cavity through the lung. If then, owing to a valve-like action of the tear in the wall of the lung cavity, this air is prevented from returning through the bronchus as easily as it entered, the pleural cavity will continue to fill with air, until the intrapleural pressure forces it out between the 2 ribs that have been separated. In consequence, a subcutaneous emphysema will result, the closure of the skin, as a rule, preventing the air from passing out. The probability also exists that the pleura will be infected from the lung cavity. In my case, an injury to a large cavity did occur, and extensive subcutaneous emphysema ensued, but at first no infection of the pleura resulted, the patient's temperature after the end of the first week being within normal range, although for many weeks previous it had been as high as 102° or 103° in the evening, with considerable remissions in the morning. Later, however, an infection manifested itself. This being the first case in which the operation was attempted, a short history will be in order:

Mrs. K. W., 30 years old, has been coughing for a long time, more so in the last 2 months than previously. For 5 weeks she has had daily chills followed by fever. She is very weak, very anemic, and poorly nourished. Chest expansion poor, especially on the left side. Over the entire left lung subcrepitant râles are heard both on inspiration and on expiration. In the upper part bronchial and bronchovesicular breathing is heard. At the right apex are many inspiratory and expiratory râles and harsh breathing.

Seven weeks after her admission to the hospital the patient was brought under my observation with the request that the pneumothorax treatment be given. On examination I became convinced that the left lung was adherent to such an extent as to render that treatment impossible. I also found the evidence of a large cavity in its upper part. A pair of stereoscopic X-ray plates, one of which is reproduced in Figure 30A, revealed an extensive tuberculous process in the left lung. Between the fourth and sixth intercostal space, near the root, a large cavity partially filled with material is seen. Marked and extensive pleuritic adhesions are present, drawing the heart well over to the left. These adhesions are also displacing the trachea and the bronchial tree well to the left. The left bronchus can be distinctly seen to be in direct communication with the large cavity. There is also an involvement of the upper and middle lobes of the right lung.

The operation was performed as described above under intratracheal insufflation anesthesia. The lung did not collapse on opening the pleura, owing to dense adhesions all over the lung attaching it to the parietal pleura. They were firmest at the apex, requiring the use of scissors at one place to liberate the lung. The collapse of the lung was not complete, owing to the infiltration of the organ, which was most marked in the upper lobe. The surface of the lung was studded throughout with tubercles of greater or less size. On mopping the pleural cavity previous to closing it, some broken-down tuberculous material was seen on the gauze mop, an evidence that the cavity in the lung had been injured. The thorax was closed without drainage.

Soon after the completion of the operation a subcutaneous emphysema developed which spread rapidly over the trunk, and after some time also involved the left side of the face. On the following day it extended over the whole face. The explanation of this occurrence is evident. Inasmuch as the injured lung cavity was in direct communication with a bronchus, the inspired air easily gained access to the pleural cavity but, owing to a valve-like action of the lacerated tissues, could not readily return the same way. The pressure of air in the pleural cavity, therefore, increased until the air was forced out through the wound in the chest wall but not through the skin, which had been adapted more accurately than the deeper layers.

The emphysema began to subside on the fourth day and was no longer visible at the end of 2 weeks, though the crackling of the air could still be felt. On the second and third day after operation the patient coughed frequently, but subsequently very little, the cough being completely absent for several days in succession. On the first 4 days occasional marked dyspnea was noted; this subsided later on. The temperature rose at first, then declined, and at the end of the first week fluctuated between 99° and 100° F. An X-ray picture (Fig. 30b), taken 9 days after the operation, reveals a complete collapse of the left lung, the pleural cavity being filled with air. The mediastinal contents, including the heart, are now markedly displaced to the right. The cavity in the lung can no longer be seen. On comparing the 2 plates, the first impression is as if the second plate had been reversed, as the right half of the thorax, which harbored the better lung, now presents the hazier picture, while the more diseased left side, on account of the pneumothorax, is, of course, perfectly clear. Toward the end of the second week the temperature rose again, and in the course of the third week the presence of a discharge proved that an infection had taken place. After this had been satisfactorily evacuated, the temperature dropped again. The patient's chances now seemed favorable, but in the beginning of the fifth week a profuse and intractable diarrhea set in which weakened the patient to such an extent that she succumbed within 2 days after its onset.

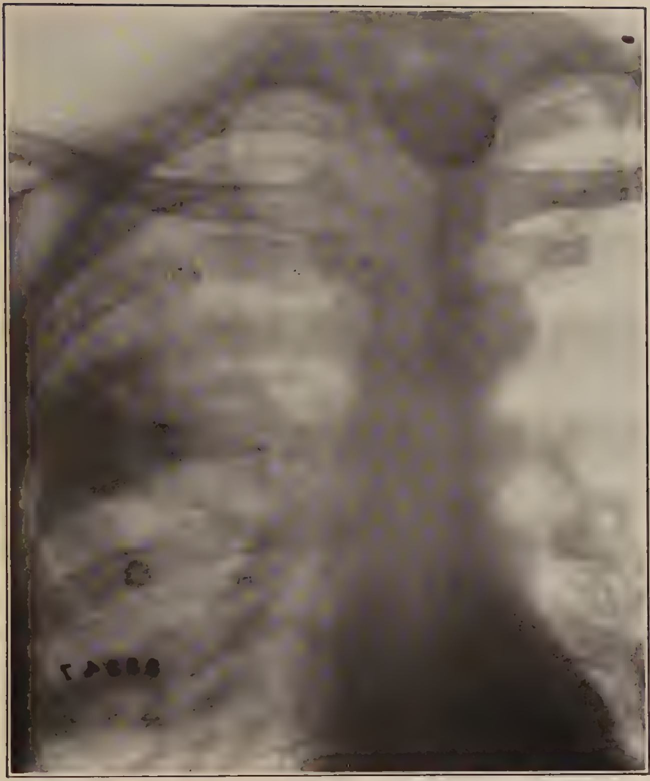
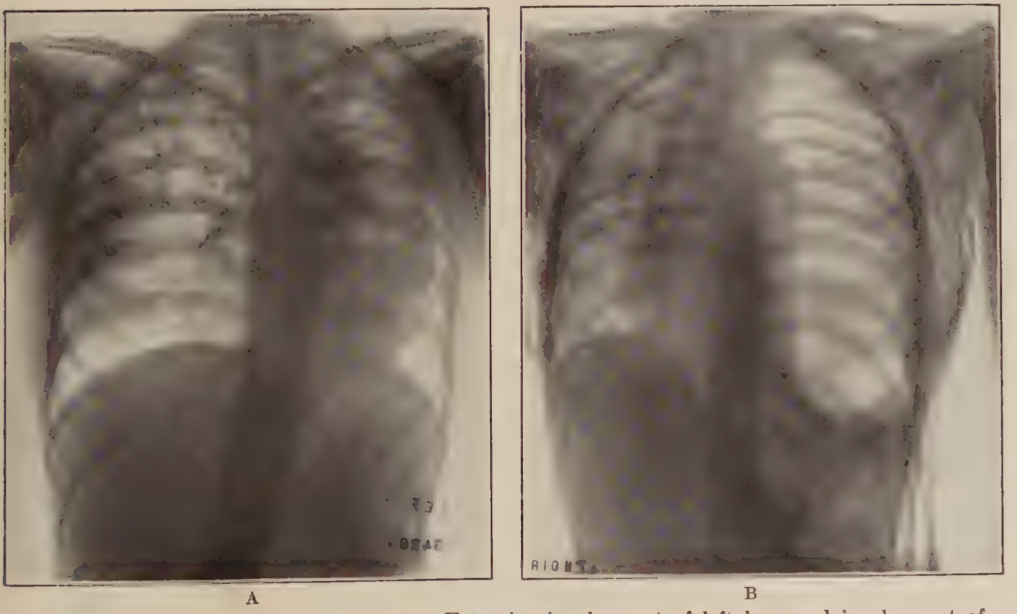


Fig. 6.—Diverticulum of Esophagus. Author's Case.



A

B

Fig. 30.—A, Pulmonary Tuberculosis. Extensive involvement of left lung and involvement of upper and middle lobes of right lung. A large cavity in the left lung near its root. The adhesions in the left pleura have drawn the heart, trachea, and bronchial tree well to the left. B, Nine Days After Operation of Interpleural Pneumolysia. Left lung completely collapsed. Left pleura filled with air. The mediastinal organs are now markedly displaced to the right. The lung cavity is no longer to be seen. Note the subcutaneous emphysema at the margins of the picture.

From the experience gained in this case it seems that the most important point in the performance of the operation is to avoid opening a lung cavity. Having had no previous experience as a guide, the danger of injuring such a cavity was not appreciated, but it seemed to me that the matter of prime importance was a speedy completion of the operation. We should, however, give our first consideration to care in separating the adhesions, even if a few minutes more are consumed in operation. If the site of the cavity is as near to the median line as that shown in Figure 30, A, we might even consider leaving the adhesions over that part of the lung untouched, as their presence would not prevent the lung from sinking in toward the mediastinum. Finally, if we have reason to suspect that a cavity has actually been opened, we should locate the lesion by inflating the lung and close it with Lembert sutures after having allowed the lung to collapse.

In cases where no injury to a lung cavity has occurred, the air in the pleural cavity will doubtless be absorbed in the course of time, so that a refilling with nitrogen will be necessary, as in the ordinary pneumothorax treatment. This refilling would be done by the puncture method described above.

While it is impossible to estimate the ultimate value of this procedure from the experience gained in a single case, yet some deductions of importance may be drawn. In the first place, the operation itself was well borne by the very weak patient, who was declared by the visiting physician of the hospital, Dr. Richard Stein, to be an absolutely hopeless case near death. Furthermore, there were the marked diminution of the cough after the third day, the drop of temperature to practically a normal range in the second week, and the disappearance of the cavity in the X-ray picture, not to speak of the subjective improvement. I therefore feel justified in expressing my opinion to the effect that the operation of *interpleural pneumolysia* is indicated in cases of pulmonary tuberculosis where the ordinary pneumothorax treatment would be indicated, but where the extent of the adhesions is so great that it either cannot be executed at all or would bring about only an imperfect collapse of the lung. In cases of bronchiectasis a similar indication would hold good.

I. HYDATIDS

Echinococcus of the lung, which is recognized either by means of an X-ray picture or from expectorated material, is curable, if it is a unilocular cyst, the usual variety. It should be attacked by operation whenever the diagnosis is certain. Probatory puncture should not be made on account of the danger of spreading the disease. The seat of the cyst is accurately ascertained by a radiograph. The affected part of the lung is exposed by resection of one or more ribs. If the lung is adherent to the pleura, the cyst is opened, its contents emptied, and the cavity tamponed. If there are no adhesions, the lung is first sutured to the pleura and is opened at a second sitting, when adhesions have formed, usually about a week later. Small cysts may be completely extirpated and the lung sewed up by deep sutures.

Operations for echinococcus are quite successful, the failures averaging only about 10 per cent.

J. OPERATION FOR EMPHYSEMA OF THE LUNGS

In cases of marked emphysema of the lungs, with a barrel-shaped thorax, a permanent inspiratory position is maintained by the calcification of the costal cartilages. Freund's operation has for its purpose the mobilization of the chest wall, so that it may be enabled again to assume the expiratory position. This is accomplished by a bilateral resection of the upper costal cartilages and sometimes the adjacent portions of the ribs. The second, third, and fourth cartilages are regularly removed, rarely the first, sometimes also the fifth and sixth.

The operation is performed in 2 or more sittings. The use of differential pressure is of advantage, as accidental injury of the pleura may occur. Differential pressure, however, is by no means a necessity, and the operation has often been performed without it. An incision, 1 to 2 cm. (about ½ in.), laterally to the border of the sternum, is made from the second to the sixth costal cartilage and deepened down to the pectoralis major muscle. The costal cartilages are exposed by separating the fibers of the pectoralis major muscle. The perichondrium is incised, and the cartilage is cut off subperichondrially with a small rongeur for about 1 cm. or more (about ½ in.). Sometimes the resection is made to include the end of the rib. Some surgeons also resect the posterior perichondrium to prevent regeneration of the cartilage, a procedure which requires great care to avoid injuring the pleura. Others implant muscle to prevent the edges of the divided cartilages from re-uniting, a flap of pectoralis major muscle with a mesial pedicle being interposed. This flap is depressed into the gap, and the adjacent fibers of the pectoralis are sutured over it.

After this operation, the rigid thoracic walls are again rendered more movable, dyspnea is lessened, and the patient's condition is improved. However, a few deaths have been recorded, the patients having manifested symptoms of severe respiratory disturbance after the operation. Breathing exercises are indicated after recovery from the operation.

K. RESECTION OF THE LUNG

Partial resection of the lung, together with resection of the thoracic wall for tumor of the latter extending to and involving the lung, has been done from time to time. The procedure is described under Operations for New Growths of the Ribs (page 533).

Indications.—Resection of larger portions of the lung is done in cases of tumor of the lung. In addition to tumors, an indication for resection may occasionally be found in certain cases of chronic inflammatory processes, actinomycosis, and bronchiectasis.

Technic.—The operation is performed under intratracheal insufflation or differential pressure. It may be rendered bloodless by passing a thin elastic ligature around the hilus or by the use of Friedrich's clamp, which is so constructed that it compresses the vessels but not the bronchus. If portions near the rim are to be resected, a clamp similar to Doyen's intestinal clamp (Fig. 22) may be used. The lung is resected and the stump sutured. Several such operations have been done successfully.

An entire lobe has been successfully resected by Gluck with the aid of a clamp applied at its root and a ligature at the site of the clamp. As a rule, however, where entire lobes are removed, the patients die from mediastinitis or mediastinal emphysema. These complications arise from the retraction of the stump of the bronchus into the mediastinum, after the ligature has cut through the bronchus. The closure of the bronchus is not reliable. There are various methods of closing it. Garré leaves a portion of lung tissue attached to the bronchus and sutures it over the stump. Tiegel and Friedrich resect or burn the mucosa and suture the end. Willy Meyer crushes the bronchus, ligates it, invaginates the tied end, and covers it by additional sutures.

For the amputation of the lower lobe an incision in the sixth intercostal space gives good access. The lobe is isolated from the rest of the pleura by tampons and is drawn forward to expose the root. The vessels are isolated and tied. The bronchus is divided as far distally from the hilus as possible and closed in one of the above-mentioned ways. The remaining part of the lung is inflated on closing the thorax to dispel the pneumothorax as much as possible.

In resection of the lung for inflammatory disease, isolation of the separate structures cannot be done, nor is it necessary. The remaining lung and pleura in those cases are apt to be separated from the field of operation by thick pleural adhesions. The resection proceeds gradually from the periphery toward the hilus, and there the lung tissue, the bronchus, and the vessels are tied by a mass ligature. The bronchus here will not recede into the mediastinum.

OPERATIONS ON THE BRONCHI

A. SUTURE OF THE BRONCHUS

Suture of the bronchus may become necessary on account of injury or after incision for the removal of foreign bodies. The sutures should not include the mucosa, preferably only the peribronchial tissue. Interrupted silk sutures are used. Tiegel recommends, as the mode of access, an incision in the second intercostal space, made as long as possible, and division of the third rib posteriorly, after which the ribs are spread apart. The upper lobe is then turned down into the anterior part of the pleural cavity, so that the posterior surface of the hilus is exposed. As the bronchus lies behind the vessels, it is best reached from the posterior aspect. In case of a complete transverse tear of the bronchus, the anterior portion would be sutured first, then the posterior. The principle of the Lembert intestinal suture is followed, inverting a small edge of the bronchus. For longitudinal sutures, Tiegel recommends reefing a considerable amount of peribronchial tissue in the end sutures and placing a margin of lung tissue over the suture line. The ends of the above-mentioned terminal sutures serve to hold down the piece of lung tissue.

Torek, in the course of a resection of the esophagus for carcinoma which was attached to the bronchus, cut into the bronchus, making an opening about 2½ cm. (1 in.) in length. This was closed with interrupted silk sutures, the aorta being drawn aside. The wound healed without any untoward symptoms. Neither pneumothorax nor infection followed, nor did mediastinal emphysema occur, although, of course, the mediastinum was open.

B. FOREIGN BODIES IN THE BRONCHI

If the efforts to remove a foreign body with the aid of the bronchoscope fail, it becomes necessary to attempt its removal by bronchotomy. The approach is from behind, as the vessels lie farther forward than the bronchus. In one case the fifth to the eighth ribs were resected posteriorly, and in another case an osteoplastic flap embracing the same 4 ribs was raised. Again, in a case where the foreign body had descended still further, it was reached by the combined use of the bronchoscope and thoracotomy through the seventh, eighth, and ninth ribs. The method of closing the incision in the bronchus is described under Suture of the Bronchus. If an abscess of the lung complicates the condition, it is drained.

C. POSTERIOR BRONCHOTOMY FOR RETROGRADE RESPIRATION

This procedure was recommended by Gluck for deep-seated obstruction to respiration. He recommends the following procedure: A flap from the fourth to the ninth intercostal space is made, the arm being raised as high as possible, in order to move the scapula away from the spine. Then the fifth to the ninth ribs are resected at their angles to the extent of about 2 cm. (1 in.) each, and the soft parts corresponding to the area of the resected ribs are divided from above downward. Then intercostal incisions are made in the fourth and ninth spaces, and a flap is reflected outward together with the ribs, which are fractured. The bronchus is found about 7 cm. (3 in.) deeper than the ribs. Its incision would enable the patient to breathe through the bronchus. The operation has been tried, unsuccessfully, in a case of aneurysm of the aorta causing asphyxia. As a substitute for this operation, Küttner recommends making a lung fistula with entrance into one of the larger bronchi, preferably the main bronchus of one lobe.

D. BRONCHOLYSIS

After his failure with posterior bronchotomy, just described, Gluck operated successfully in another case of asphyxia due to compression of the bronchi by an aortic aneurysm. He resected 12 cm. (5 in.) of the seventh and eighth ribs, when the pleura was injured and the patient collapsed. The lung was grasped.

drawn forward, and securely attached to the pleura by sutures. The patient, who, previous to the operation, was partly unconscious owing to asphyxia, was able to breathe deeply after the operation. Gluck's explanation of this result is that the traction on the lung, made permanent by the pneumopexy, released the 1 bronchus out of its embrace by the aorta—in other words, the compression of the bronchus was relieved by broncholysis.

OPERATIONS ON THE MEDIASTINUM

Anatomical Points.—The 2 pleuræ do not meet in the middle of the thorax, but leave a space called the mediastinum. Although this is a single space, it is described, for practical reasons, as being divided into 2 parts called respectively the anterior and the posterior mediastinum. The imaginary plane dividing them is a frontal plane tangent to the posterior border of the trachea and bronchi. In the anterior mediastinum, therefore, we have the thymus, the arch of the aorta, the pulmonary artery, the superior vena cava, the innominate veins, the phrenic nerves, the trachea, and the bronchi. The posterior mediastinum contains the esophagus, the thoracic aorta, the azygos and hemiazygos veins, the vagi, the sympathetic nerves, and the thoracic duct. The heart lies in both the anterior and the posterior mediastinum.

A. ANTERIOR MEDIASTINOTOMY

The anterior mediastinum is entered for the purpose of draining abscesses and for removing tumors. The operation may also be indicated in cases of enlargement of the thymus gland. In a few instances dermoid cysts have been successfully removed after resection of the sternum. The most frequent tumors in the anterior mediastinum are the retrosternal goiters (see chapter on Thyroid Gland).

Abscesses in the anterior mediastinum, often in connection with phlegmonous processes in the neck, caused by foreign bodies in the pharynx or esophagus, are treated by extensive incisions in the neck and resection of the costal cartilages corresponding to the location of the abscesses. Partial resection of the sternum may be necessary to reach a mediastinal abscess. If the sternum has to be resected for abscess, the resection is an atypical one and consists in subperiosteal removal of a portion of the sternum by means of gouge, mallet, and rongeur. After a sufficient portion of bone has been removed, the posterior periosteum is incised carefully. Usually the pus will be at once apparent; if not, it is cautiously searched for, exercising particular care to avoid injury to the great vessels. Negative differential pressure aids in the evacuation of the pus and is superior for this purpose to positive pressure or intratracheal insufflation. The use of rubber drainage tubes in the vicinity of the large vessels is dangerous, as injury to the walls of those vessels may result. If rubber tubes are used, they must be well protected by gauze.

Resection of the Sternum.—For the removal of tumors in the anterior mediastinum an osteoplastic resection of the manubrium may be performed. The resection of a large portion of the sternum is an operation of considerable magnitude, as it may be complicated on the one hand by hemorrhage either from the internal mammary artery and its branches or from the veins which are particularly apt to be dilated in cases of new growths, or, on the other hand, by the danger of injuring both pleuræ. For the latter reason the operation should be undertaken under differential pressure or intratracheal anesthesia.

Resection of the manubrium is more difficult than that of the body of the sternum (Fig. 31). Kocher recommends the performance of an osteoplastic resection of the manubrium. An incision is made from the mesial end of the right clavicle to the mesial end of the left clavicle, thence downward to a little below the second left costal cartilage, and back again to a corresponding place below the second right costal cartilage. The upper transverse incision is deepened down to the bone, separating the capsule of the sternoclavicular joint and the sternocleidomastoid muscle on each side from the bone. In the depth of this cut the insertion of the sternohyoid and sternothyreoid muscles is also divided. Now, the left sternoclavicular articulation is completely opened and divided down to the first costal cartilage; then the second costal cartilage is exposed and divided close to the sternum, after which the first costal cartilage is also divided subperichondrially and the remainder of the capsule of the sternoclavicular joint is cut through. The manubrium is now raised with a

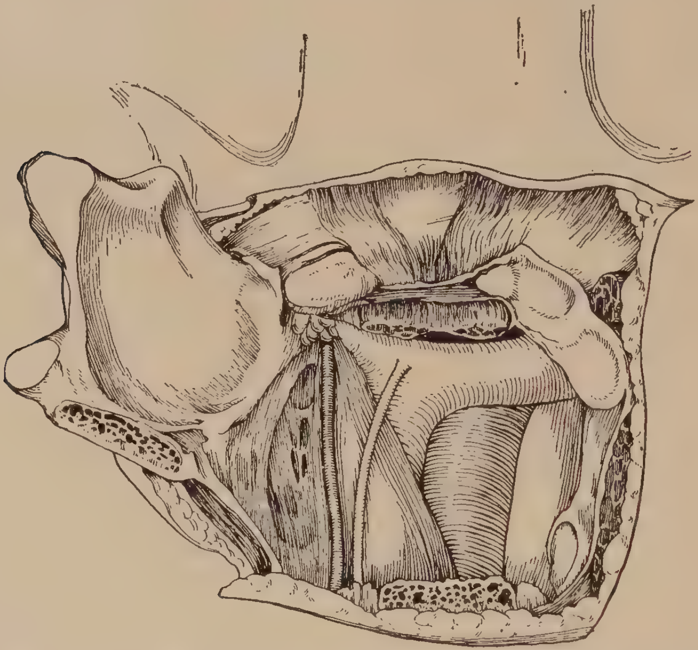


FIG. 31.—KOCHER'S OSTEOPLASTIC RESECTION OF THE STERNUM. The manubrium has been turned over to the right side.

sharp hook to liberate its posterior surface and to divide it transversely from the body of the sternum. The elevation of the manubrium is carefully continued, and the cartilages on the other side are broken.

If the object is to make not a temporary, but a permanent resection of the manubrium, the skin flap is separated from the bone at the beginning of the operation, and the bone is afterward removed.

Another method of exposing the mediastinum is by splitting the sternum in its entire length in the median line. Still another method is the transverse division of the sternum at the upper border of the third rib and extension of the incision outward for 10 to 12 cm. (4 to 5 in.) in the second intercostal space on each side, care being exercised to avoid injury to the pleura. The costal cartilages above and below the incision are divided 3 cm. (1¼ in.) from the borders of the sternum, that is, laterally to the internal mammary arteries. The 2 halves of the sternum are drawn upward and downward to expose the mediastinum. In the further course of the operation the pleuræ will usually be injured, but it is well to keep them intact as long as possible. A similar incision, either at the level of the third or fourth intercostal space, gives good access to the base of the heart.

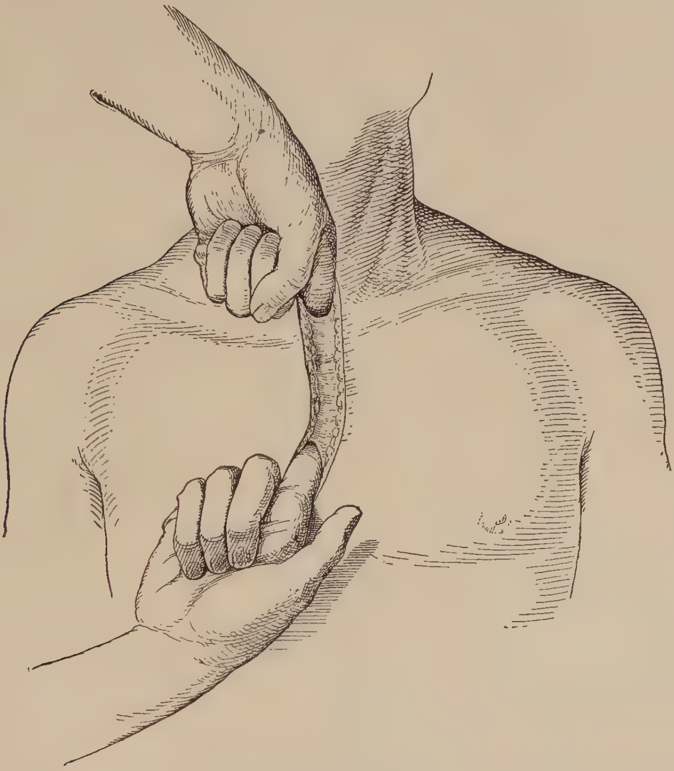


Fig. 32.—Sauerbruch's Longitudinal Mediastinotomy. The fingers are introduced behind the sternum.

Sauerbruch recommends as a method of access an incision in the median line dividing the sternum from its upper border down as far as the level of the third rib, thence turning out into the third intercostal space. The skin incision runs in the median line from the cricoid cartilage to the level of the third rib, then turning into the intercostal space. In the neck the soft parts are divided down as far as the sternohyoid muscles; over the sternum the incision goes down to the bone. At the intercostal space the fibers of the pectoralis major muscle are separated close to the sternum, the internal mammary artery and vein are tied and divided, and the pleura is exposed. The sternohyoid muscles are separated bluntly, and the index finger is cautiously inserted into the depth close to the posterior surface of the sternum (Fig. 32). The other index finger is interposed between the separated fibers of the pectoralis, the pleura is carefully pushed to the lateral side, and the finger is insinuated further into the mediastinum, keeping close to the sternum until the fingers meet. Thus the great vessels are separated from the sternum and protected against injury, when the bone is cut. While the 2 fingers are under the sternum we may be able to make out whether the tumor

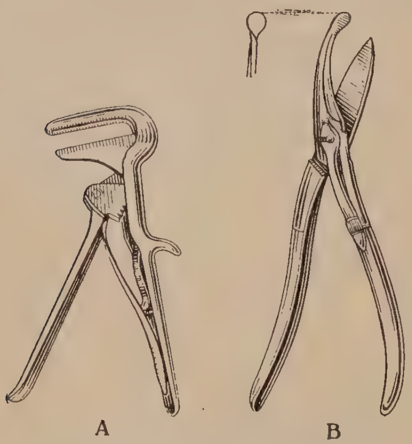


Fig. 33.—A, B, Two Kinds of Schumacher's Sternum Shears.

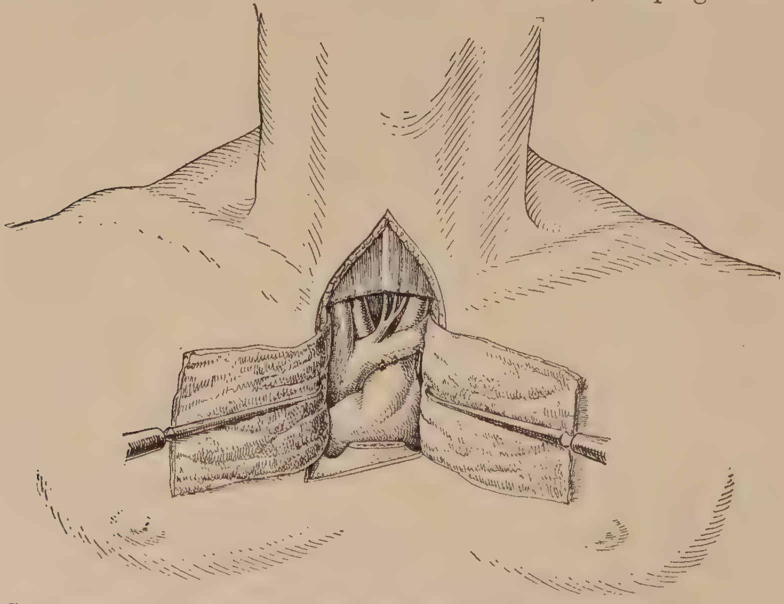


Fig. 34.—Sauerbruch's Longitudinal Mediastinotomy Combined with Transverse Division of the Sternum.

is operable or not, and we decide whether to leave the bone intact or to divide it for extirpation of the tumor, or, in case of inoperability, whether we should resect a large piece of the sternum in order to expose the tumor subsequently to the X-rays. The division of the bone is done under the guidance of the finger with a special bone cutter (Fig. 33, A). The cut edges of the bone are covered with gauze compresses and drawn apart, when the structures of the mediastinum will be exposed to view.

Still better access, though rarely necessary, is obtained by dividing the sternum transversely across at the lower end of the longitudinal incision (Fig. 34). This is readily done with the aid of appropriate bone-cutting shears (Fig. 33, B), care being taken not to injure the pleura. On removing the tumor, all its vessels, whether arteries or veins, must be carefully ligated. The divided bone is reunited with strong silk sutures and the skin is sutured without drainage.

The operations on the pericardium and heart are described in a separate chapter.

B. POSTERIOR MEDIASTINOTOMY

Indications.—Various indications have been given for the performance of posterior mediastinotomy. One of these is the presence of foreign bodies in the intrathoracic portion of the esophagus. If one considers the great success achieved by esophagoscopy in removing even such bodies as sharp pieces of bone and sets of artificial teeth (see Vol. III, Chap. X), posterior mediastinotomy with its great dangers will scarcely be attempted, except when other methods have failed.

Another indication is stricture of the esophagus in its intrathoracic portion. Posterior mediastinotomy has been tried for this purpose (Rehn, Potarca), but as yet no successful case has been reported. The treatment of esophageal stricture is described under Introduction of Sounds and Esophagotomy.

Tumors of the esophagus seemed to present an important indication for posterior mediastinotomy. This has been attempted (Rehn), but with a fatal outcome. For the methods of resecting the esophagus in its intrathoracic portion, see under the corresponding heading (page 510).

A clear indication for posterior mediastinotomy is found in abscess, whether caused by perforation of the esophagus through neglected foreign bodies or disease of the lymphatic nodes or vertebræ. Tiegel has also cured a case of mediastinal emphysema by cervical mediastinotomy combined with the use of a Bier suction cup, the suction being made continuous by the attachment of the cup to a water pump.

Technic.—There are 2 ways of attacking this region, cervical and dorsal mediastinotomy. The 2 may also be combined. For exposing the upper part of the posterior mediastinum, cervical mediastinotomy will answer. It is the easier procedure, beside being less dangerous. It affords access as far down as the third dorsal vertebra.

CERVICAL MEDIASTINOTOMY.—Cervical mediastinotomy may be performed on either side of the neck. If a phlegmon points on one side, or if a sinus exists, there will, of course, be no doubt on which side we should enter. If no sinus exists and there is no distinct evidence of phlegmon, the patient is placed in Trendelenburg's position for some time, and an area of redness over one clavicle may then be seen, indicating on which side the incision should be made. The incision is made above the clavicle, parallel to it, dividing the clavicular attachment of the sternocleidomastoid muscle. Then the operation proceeds into the depth above the sternoclavicular articulation. On the left side Heidenhain recommends going down on the lateral side of the carotid artery and jugular vein; on the right side, between them. v. Hacker prefers going down on the mesial side of the vessels. The localization of the phlegmon will probably determine the path to select in the individual case. If rubber drains are used, they must be protected by gauze to prevent injury to the vessels. To promote drainage, the dependent position, Trendelenburg's posture, is maintained.

DORSAL MEDIASTINOTOMY.—Dorsal mediastinotomy is to be performed in those cases in which the seat of the abscess cannot possibly be reached from the neck, and also where cervical mediastinotomy has failed. In the latter case the operation will be a combination of cervical and dorsal mediastinotomy. Several cases have been cured by this method. If an external sinus exists in the neck, communicating with the abscess, the lower border of the abscess may be determined by injecting a bismuth mixture and taking a radiograph. This will demonstrate the site where dorsal mediastinotomy should be performed. It consists in resecting the posterior ends of a number of ribs between their angles and the vertebræ. It may be performed on either side of the spine. On the left side the aorta is a troublesome obstacle, on the right side the pleura. The difficulties are great either way, yet it seems that the right side is preferred for the approach.

Rehn has entered through a longitudinal incision midway between the spinous processes of the vertebræ and the mesial border of the right scapula. The incision is carried down to the ribs, 3 or 4 of which are resected subperiosteally, several cm. (1 in. or more) of their mesial ends being removed. The intercostal muscles, nerves, and vessels are divided, the latter being first doubly ligated. Great care must be exercised on proceeding into the depth. One should keep rather close to the lateral surfaces of the bodies of the vertebræ, carefully avoiding injury to the sympathetic nerve and, if the esophagus is the aim of approach, separating the right vagus nerve and the azygos vein from it. The latter may be tied. Injury to the pleura has often occurred and has caused death through infection.

Heidenhain has shown how to avoid this great danger, the injury to the pleura. His incision is close to the median line. The soft parts are resected from the right sides of the arches, until the transverse processes of the vertebræ appear. Sometimes a transverse incision through the muscles is added. Now one or more transverse processes are resected together with the initial portions of the corresponding ribs. The transverse processes are divided with bone shears, and the ribs are liberated subperiosteally and cut just beyond their tubercles. This method, a combination of the removal of the transverse processes with resection of the ribs, transposes the seat of operation nearer to the median line and thus avoids injury to the pleura. The operation is called *costotransversectomy.* After careful division of the periosteum, the finger can enter the mediastinum to the necessary depth, about 10 cm. (4 in.), and the pleura, together with the thin endothoracic fascia, can be pushed aside with a minimum of danger. If the diagnosis was correctly made, the finger enters the abscess at the lateral and anterior surface of the bodies of the vertebræ. Even the removal of a single transverse process and the adjoining portion of rib suffices to gain entrance into the mediastinum, which, in case of abscess, is of particular value. In abscess due to tuberculosis of the spine, the X-ray picture shows which transverse process or processes should be attacked. Pieces of necrotic bone may thus be removed.

Kocher has modified Heidenhain's costotransversectomy by making a transverse incision outward and downward through the muscles in the course of the rib to be resected. The bleeding is less than that experienced in dissecting the muscles from the spinous processes and arches in Heidenhain's method. The transverse division does no harm to the muscles, as they are amply supplied with nerves.

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CHAPTER XII

SURGERY OF THE PERICARDIUM AND HEART

EUGENE H. POOL

Rehn, in 1896, demonstrated the possibility of successful operative intervention in wounds of the heart; cardiac surgery then passed beyond the experimental stage. Since that time the technic of cardiorrhaphy has progressed materially, but the practical application of surgery to the heart has not been extended beyond the treatment of wounds.

As a result of the development of differential pressure, thoracic surgery has made striking advances in recent years and experimental work upon the heart and great vessels has been entered into with renewed enthusiasm. The correction of interference with the mechanism of the heart through valvular disease is the dream of most experimenters, but the impaired condition of the patient and the dangers of hemorrhage and infection will be strong deterrent factors in the application to man of valvular surgery. It is at present impossible to foresee the practical utilization of the ingenious procedures that have been applied more or less successfully in the experimental surgery of the heart.

The *pericardium,* as a closed sac enveloping the heart, presents well-defined indications for surgery, such as the removal or drainage of inflammatory exudates, the relief of a heart restricted by an adherent pericardium, the treatment of wounds, and the removal of foreign bodies. But the possibilities of immediate radical advances in connection with the surgery of the pericardium appear limited. In the following consideration of the surgery of the heart and pericardium experimental work will not be discussed at length; it appears unwarranted in a practical work to enter deeply into this phase of the subject.

ANATOMY OF THE PERICARDIUM AND HEART

The Pericardium.—The heart and, for a distance of about 5 cm., the first segment of the large blood-vessels are inclosed in a serous sac, which, like other serous sacs, is composed of 2 layers, the visceral and parietal. The parietal layer is strengthened by an outer fibrous layer. The serous sac and its fibrous covering together constitute the pericardium. The pericardium is somewhat conical in shape, the broad base of the cone resting upon the diaphragm, the apex pointing upward. The fibrous layer or sac is in part incorporated with the fibers of the central tendon of the diaphragm and is loosely attached to the adjacent part of the diaphragm, extending further into the left than into the right side of the thorax. Above, it blends with the fibrous sheaths of the great vessels. The fibrous sac is resistant and rather inelastic, which explains the serious disturbance of the heart action which may result from the rapid and extensive accumulation of fluid within the pericardium.

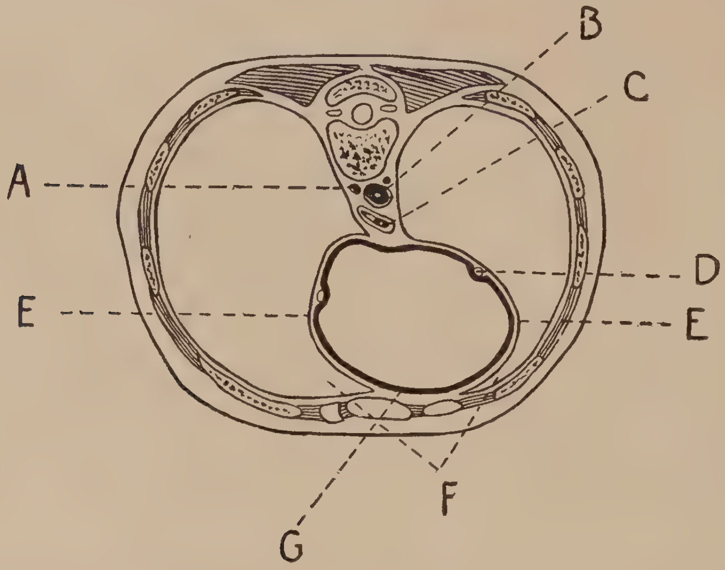

Fig. 1.—Transverse Section through Thorax of 2¾ Year Old Child (Corning). A, V. azygos; B, aorta; C, esophagus; D, phrenic nerve; E, mediastinal pleura; F, anterior reflexion of pleura; G, pericardium.

The serous layer lines the entire pericardial cavity. At the base of the heart it is reflected from the fibrous layer on to the vessels, thence over the surface of the heart which it closely invests. This layer incloses the aorta and pulmonary artery in a single sheath. The remaining vessels do not receive complete coverings. The inferior vena cava has only a slight covering; it enters the right auricle almost immediately after penetrating the diaphragm. The superior vena cava is covered on its anterior surface. Small niches on the right and left side correspond to the pulmonary veins. There is a gap or cleft between the aorta and pulmonary artery in front and the auricles behind, which is known as the transverse pericardial sinus. The lowest point of the pericardium is in relation with the anterior thoracic wall below the base of the xyphoid process; the pericardium is here reflected from the diaphragm to the sternum, leaving a gap which is not filled by the heart but contains a small amount of clear fluid. With this exception, the pericardium in the living subject is filled by the heart, the 2 serous surfaces being in contact during the entire cardiac cycle.

The pericardium has been divided into diaphragmatic, mediastinal, and sternocostal portions, according to the relation of the parietal layer to adjacent structures. The sternocostal portion, although the smallest, is surgically the most important. This small portion of the anterior surface is left uncovered by pleuræ and lungs and is in contact with the anterior thoracic wall in an area outlined by the 2 divergent anterior limits of the pleuræ. Laterally, the pericardium is in contact with pleura; a phrenic nerve passing downward on each side on its outer surface. Posteriorly, the pericardium is in contact with the roots of the lungs, esophagus, and aorta.

The blood supply of the pericardium is derived chiefly from the aorta, but the internal mammary artery gives off branches to the anterior surface. The veins accompany the arteries and enter the azygos and internal mammary veins and superior vena cava. The nerve supply of the pericardium is chiefly derived from the left phrenic nerve, supplemented by the right phrenic, the pneumogastrics, and sympathetic. The lymphatics enter the mediastinal nodes.

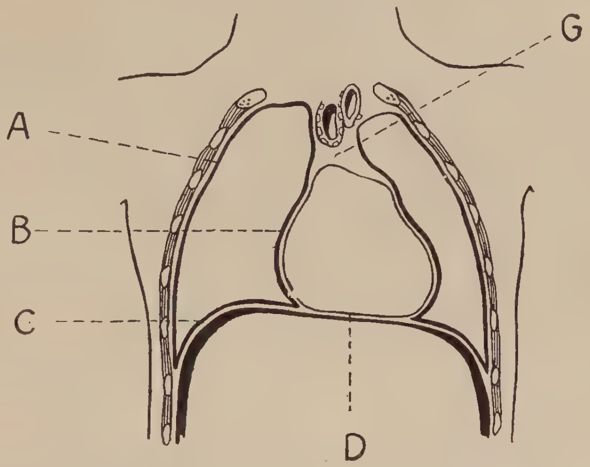

Fig. 2.—Frontal Section through Thorax (Corning). A, Costal pleura; B, mediastinal pleura; C, diaphragmatic pleura; D, pericardium; G, mediastinum.

The pericardiosternal ligaments attach the pericardium above and below to the manubrium and ensiform process of the sternum; the pericardiovertebral ligaments pass from the prevertebral fascia to the apex of the sac, while the pericardiophrenic ligaments extend from its posterior surface to the upper surface of the diaphragm.

The Heart.—The heart, inclosed in the pericardium, lies in the mediastinal portion of the thoracic cavity between the 2 lungs and their pleural coverings. It is conical in shape and occupies an oblique position. The base, corresponding to the level of the sixth, seventh, and eighth dorsal vertebræ, is directed upward, backward, and to the right. The apex is directed forward, downward, and to the left; it normally lies beneath a point in the fifth intercostal space about 9 cm. (3½ in.) from the midline. At its base the heart is connected with the great vessels which render this portion relatively fixed, while the remainder, from base to apex, lies free within the pericardial sac. The anterior surface is convex and is directed upward and forward toward the chest wall; the inferior or posterior surface is flattened and rests upon the diaphragm. The surfaces are united anteriorly (or inferiorly) and to the right by a sharp border and posteriorly (or superiorly) and to the left by a thick rounded border.

The 4 compartments which comprise the heart vary greatly in the structure of their walls and in their relationship to the chest wall. The left ventricle, conical in shape, forms the apex, left border, a small part of the anterior surface, and a large part of the inferior surface of the heart. The thickness of its wall is approximately 1.6 cm. at the middle of the cavity. The right ventricle forms the greater part of the anterior surface of the heart, the acute anterior margin and part of the inferior surface, but none of the apex. Its wall is normally 0.4 to 0.6 cm. in thickness, that is, about $\frac{1}{3}$ the thickness of the wall of the left ventricle. The auricles, situated at the base, have extremely thin walls, approximately 1/12 to $\frac{1}{8}$ in. in thickness; from each auricle projects a tongue-like process, the auricular appendix.

The limits of the ventricles are evidenced superficially by furrows, the interventricular grooves, 1 on the anterior surface near the left margin of the heart and 1 on the posterior surface near the acute margin. Near the base, the ventricular and auricular portions of the heart are separated by a transverse furrow, the auriculoventricular groove.

The 2 coronary arteries arise from the aorta and supply the walls of the heart by numerous branches which penetrate all parts of the muscle and present fine anastomoses. The left coronary artery is, as a rule, the larger. It appears between the pulmonary artery and auricular appendix and divides into a transverse or posterior and a descending or anterior branch. The latter passes downward in the anterior interventricular groove to the right of the apex. The right coronary artery arises anteriorly from the aorta and passes in the auriculoventricular groove to the right margin of the heart, where it divides into 2 branches, the transverse and the descending. The latter passes downward in the posterior interventricular groove. There is also a large branch which descends along the acute right margin of the heart.

The veins of the heart are numerous; the greater number are united into a common trunk, the coronary sinus, which empties into the lower part of the right auricle. The heart is well supplied with lymphatics, especially beneath the endocardium and visceral pericardium. Their collecting trunks enter the intertracheobronchial group (Poirier).

"The nerves, given off by the cardiac plexuses, appear rather small in comparison with the bulk of the heart; they are derived partly from the cerebrospinal and partly from the sympathetic system (more especially from the pneumogastric nerve, and from the cervical and superior thoracic ganglia of the sympathetic nerve)" (Quain).

The structure of the heart wall consists chiefly of muscular tissue. The fasciculi are arranged as an intricate network in which there are a relatively small amount of areolar tissue, many blood-vessels and lymphatics, and, in places, nerve fibers and ganglia. A variable amount of fat is present, lying chiefly beneath the visceral layer of the serous pericardium.

Relations of the Heart and Pericardium to the Thoracic Wall.—Of vital surgical interest are the relations of the heart and its parts to the thoracic wall. A brief description is here summarized, for the most part from Quain's "Anatomy." Two-thirds of the heart lies to the left of the median line. The apex is situated in the fifth intercostal space, about 9 cm. (3½ in.) to the left of the middle line, and generally about 4 cm. (1½ in.) below, and 2 cm. (¾ in.) to the sternal side of the nipple. The position of the nipple, however, is too variable for it to be used as a landmark. The upper limit of the heart is indicated approximately by a line drawn from a point slightly above the upper border of the third costal cartilage of the left side about 4.5 cm. (1¾ in.) from the median line of the sternum to a point upon the upper border of the third costal cartilage of the right side about 3 cm. (1¼ in.) from the middle line. The left margin is represented by a line, slightly convex toward the left, passing from the end of the base line to the apex point; the right margin is indicated by a line, markedly convex toward the right, drawn from the right end of the base line to the junction of the seventh costal cartilage of the right side with the sternum. (Piersol.) The lower limit is indicated by a line passing almost transversely from the sternal end of the seventh right cartilage to the apex. The area thus marked out corresponds to what is known as the deep cardiac dulness; the superficial cardiac dulness corresponds to that part of the heart which is uncovered by lung.

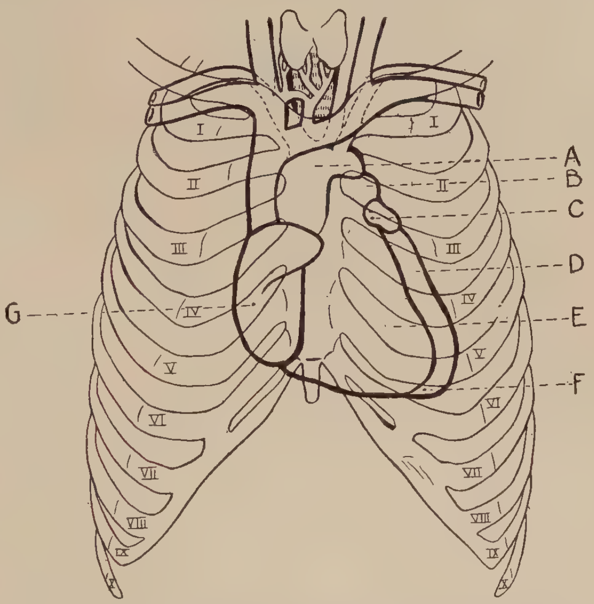

Fig. 3.—Relation of the Heart and Great Vessels to Chest Wall (Corning). A, Aorta; B, pulmonary artery; C, left auricle; D, left ventricle; E, right ventricle; F, apex; G, right auricle.

"The right auricle lies behind the anterior extremities of the third to the sixth costal cartilages and adjacent edge of sternum. The left auricle lies behind the anterior extremities of the left cartilages from the lower border of the second to the upper border of the fourth. The right ventricle, corresponding to the middle and lower region of the heart, is, as a rule, the only part uncovered by lung; but sometimes, especially during expiration, a small portion of the left ventricle at the apex is also exposed. The auriculoventricular sulcus corresponds with a line drawn obliquely upward from the sternal end of the sixth costal cartilage, on the right side, to the third cartilage on the left. The position of the heart is subject to some degree of individual variation, and the extent of the several divisions will necessarily be dependent upon the stage of their action."

The Chest Wall.—The accompanying illustration (Fig. 4) renders a description of the bony framework unnecessary. Between the ribs are the external and internal intercostal muscles, the intercostal vessels and nerves. With the exception of the external intercostal muscles the same structures lie between the respective cartilages. Anteriorly, the greater part of the thoracic wall is covered on each side by the pectoral muscles. The lower margin of the pectoralis major leaves the chest opposite the fifth rib. To the outer side of the pectoralis major the ribs are covered by the serratus magnus. Below the pectoralis the wall of the thorax is covered by the rectus abdominis internally, and the external oblique laterally. "The ribs as a rule can be palpated easily over the front and sides of the chest; with the exception of the first. The width of the intercostal spaces and the form of the subcostal angle vary greatly in accordance with the shape of the chest." Between the bony thoracic wall and the pericardium are found, besides pleura and lung, the triangularis sterni, endothoracic fascia, and internal mammary artery. The triangularis sterni is a thin triangular muscular sheet. Its origin is below from the lower third of the back of the sternum, the back of the ensiform cartilage, and the back of the inner ends of the fifth, sixth, and seventh cartilages. Its insertion is into the outer ends of the cartilages of the second to the sixth ribs. The endothoracic fascia is a thin aponeurosis immediately external to the parietal layer of the pleura. "The internal mammary artery passes downward behind the costal cartilages, and the upper six intercostal spaces, about 1 cm. (½ in.) from the margin of the sternum. The intercostal vessels for the greater part of their course lie protected in grooves beneath the lower edges of the ribs."

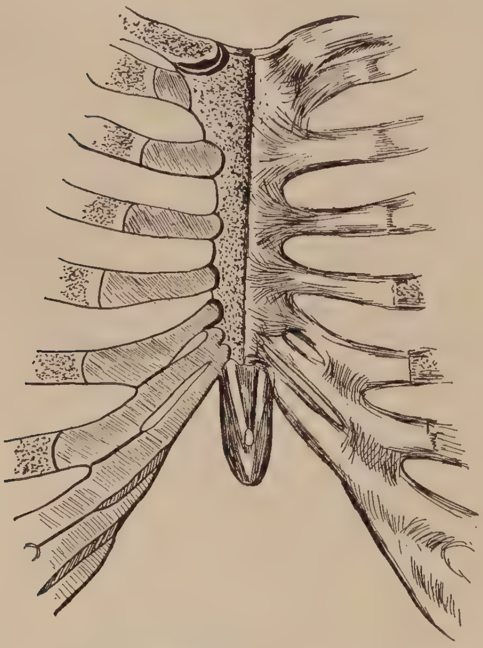

FIG. 4.—BONY FRAMEWORK OF ANTERIOR THORACIC WALL (Morris).

RELATIONS OF PLEURÆ AND LUNGS TO THE CHEST WALL.—"The anterior line of reflection of the pleura varies at different levels, and also slightly on the two sides. Opposite the manubrium sterni it may be represented by a line passing from the sternoclavicular articulation downward and inward to meet the pleura of the opposite side at the upper edge of the body of the sternum. From this point the two pleuræ are in close contact to about the level of the fourth intercostal space or upper border of the fifth costal cartilage, where they separate. On the right side the line of reflection continues nearly straight downward to the lower end of the body of the sternum, where it begins to turn outward. On the left side, according to Luschka, it normally diverges from the median line at the upper border of the fifth costal cartilage, so that at the level of the sternal end of the fifth costal cartilage it is 1.5 cm., at the sixth 2 cm., and at the seventh 3.5 cm., external to the left border of the sternum. Not infrequently, however, the lateral deviation of the left pleura opposite the lower end of the sternum is not so marked as described by Luschka."

"From the apex, the anterior border of each lung inclines inward behind the sternoclavicular articulation and the manubrium, to the junction of the latter with the body of the sternum, where the two almost meet in the middle line; thence they descend together, the right sometimes projecting a little to the left of the midline, as far as the fourth costal cartilage; from this point the margin of the right lung continues a nearly straight course to the level of the sixth chondrosternal articulation (sometimes even to the lower end of the body of the sternum), while that of the left slopes outward behind the fifth costal cartilage, in a direction which may be indicated with sufficient accuracy by a line drawn from the fourth chondrosternal articulation of the left side to the spot on the chest-wall corresponding to the apex of the heart." But this line is modified by a tongue-like process of lung, the lingula, which projects inward, and is represented by an oblique line passing from the fifth to the sixth costal cartilage. "The lower limit of the lung may be marked by a line, slightly convex downward, carried around the side of the chest from the sixth chondrosternal articulation to the tenth dorsal spine" (Quain).

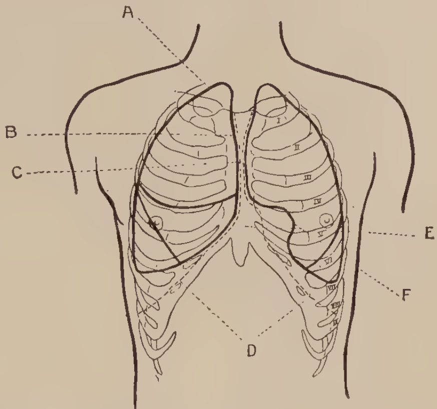

Fig. 5.—Outlines of Pleuræ and Lungs (Corning). Heavy lines, outlines of lungs, B.F. Dotted lines, outlines of pleura, C.D. E, Area in which pericardium is uncovered by pleura.

In forced inspiration the pleuræ and lungs cover the heart more than in expiration. In children the heart is about one intercostal space higher than in adults (Pels-Leusden).

OPERATIONS UPON THE PERICARDIUM

Indications.—The indications for operation upon the pericardium may be classified as follows:

1. Aspiration or drainage of inflammatory exudates.
2. Relief of a heart restricted by an adherent pericardium.
3. Removal of foreign bodies.
4. In connection with wounds: (a) for the relief of the heart when compressed by hemorrhage into the sac (hemopericardium); (b) for exploration, in suspected wounds of the heart; (c) for exposure of the heart in the treatment of cardiac wounds. The details of wounds will be deferred until the consideration of wounds of the heart.

INFLAMMATORY EXUDATES

General Considerations.—The large majority of operations upon the pericardium are undertaken to rid it of fluid contents of inflammatory origin. Therefore, the occurrence of inflammatory exudates within the pericardium demands some consideration. The pericardium is subject to the same influences as are other serous membranes. But, although the serous membrane of the pericardium is the part most conspicuous in the inflammatory process, the pathological changes are not necessarily limited to it. The process, as a rule, simultaneously involves the heart muscle (myocarditis), and subsequently it may extend to the fibrous pericardium and even to the adjacent structures of the mediastinum. The inflammatory process may be acute or chronic, circumscribed or diffuse, primary or secondary. The character of the exudate may be serous, hemorrhagic, serofibrinous, fibrinous or purulent. The amount of fluid exudate varies within wide limits, that is, from a few cubic centimeters to 1,500 or more.

The distribution of the fluid in the distended sac must be understood to appreciate the technical details of paracentesis or pericardiotomy. First, the recesses become filled, the fluid gathering chiefly in the region of the base of the heart; then the bulging pericardium, confined anteriorly, separates the yielding lungs and pushes the diaphragm downward. The increasing exudate progressively distends the pericardium, for the most part to the left and posteriorly. It must be emphasized that the heart usually occupies a low position and remains applied to the anterior wall of the thorax. Occasionally an inflammatory process may become localized by the formation of adhesions and the limitation of the exudate to a circumscribed part of the sac.

It is unnecessary to enumerate fully the organisms upon which the process may depend, or the diseases with which pericarditis may be associated. It is sufficient to call attention to the fact that pericarditis occurs as a relatively frequent complication in a large number of diseases, the most frequent of which are inflammatory rheumatism, nephritis, pleurisy, pneumonia, pyogenic infections, and tuberculosis, but there are "few infectious diseases which may not implicate the pericardium" (McPhedran).

The clinical picture of pericarditis with effusion is variable. Besides the local objective signs, the cardinal sign of exudative pericarditis being a characteristic cardiac dullness which is at first increased upward, there are present to a variable degree symptoms due to: (1) involvement of the heart muscle (myocarditis), which is the most frequent and serious lesion; (2) endocarditis (these two are especially frequent in association with rheumatism); (3) mechanical disturbance of the heart as a result of pressure exerted by the effusion; this, however, is infrequent; (4) general constitutional disturbances, depending upon the type of the infection, the pericardium offering a large surface for absorption; (5) an associated lesion or disease.

In the consideration of the surgical treatment of pericarditis certain general features in regard to serous and purulent effusions should be reviewed separately.

Serous Effusions.—It must be emphasized that **a serous effusion is usually absorbed,** that its presence rarely affects the action of the heart except when it is extremely large in amount, that the impaired heart action is due chiefly to associated myocarditis, that toxic symptoms due to serous effusions are not marked, and that any prolonged pericarditis may be associated with the formation of extensive intrapericardial adhesions which frequently produce permanent impairment of the heart action.

Indications for Treatment.—A serous effusion should be removed as soon as there is evidence that its presence embarrasses the heart. But in general the following rules should be followed: Small serous effusions should receive medical treatment; large serous effusions which persist after a brief trial of non-operative measures should be removed. If the fluid reaccumulates rapidly or in large amount, it should be removed. For the removal of serous, serofibrinous, and hemorrhagic exudates, paracentesis is the operation most frequently employed and is the one usually to be recommended. The immediate result of the removal of serous effusions is usually disappointing because the embarrassment of the heart action as a rule is not due to the presence of the fluid, but to an intrinsic myocardial incompetence.

Suppurative Pericarditis.—This condition represents an abscess corresponding to a part or the whole of the pericardial sac. The most frequent organisms are the streptococcus, staphylococcus, and pneumococcus. The exudate is usually purulent from the beginning of the attack, although occasionally it develops in the course of a non-suppurative pericarditis. As a rule purulent pericarditis is secondary in the course of a pyogenic infection, and under such conditions it frequently constitutes a "terminal infection"; in rare cases suppurative pericarditis is primary; in some cases the infection is introduced through a wound.

Suppurative pericarditis is characterized by the local signs of pericarditis with effusion and constitutional symptoms of a septic character. The fact that the pericarditis is frequently a secondary lesion causes its presence to be overlooked in many cases. In children the symptoms of pericarditis are particularly apt to be masked. On the other hand, in many cases where the lesion has been recognized and the pericardium drained, the operation has been unsuccessful because a coexisting purulent focus, especially empyema, has been overlooked. It follows that in septic processes it is necessary to watch for the development of pericarditis; moreover, the recognition of such a condition should not cause less thoroughness in the search for other foci.

Suppurative pericarditis demands immediate incision and drainage. The prognosis in purulent pericarditis is in general unfavorable, yet in suppurative processes which are confined to the pericardium early operation is quite often followed by recovery; on the other hand, where the pericardium is involved secondarily in the course of a general sepsis, recovery is infrequent. Nevertheless, cases that appear hopeless are occasionally saved by operation. Accurate statistics on this subject are not available.

Radiography of the Pericardium.—Radiography of the pericardium is of considerable practical importance. The X-ray affords reliable information as to the extent and location of a distended pericardium; in consequence, puncture of the pericardium is essentially facilitated by X-ray examination. It has been claimed recently by Roemheld that the pericardium of normal individuals can be shown by means of teleröntgenography, especially on the left side, very rarely on the right, as a semitransparent oblique strip passing inward and downward. He asserts that pathological changes, especially cicatrices or adhesions, are accentuated more distinctly than the normal pericardium.

Pericardiocentesis: Paracentesis Pericardii

Indications.—Paracentesis (puncture or aspiration) of the pericardium is employed in accumulations of serum, blood, pus, or air within the pericardial sac. Its uses may be summarized as follows (Küttner, 1912):

1. As a diagnostic adjuvant, in the form of an exploratory puncture, in order to obtain information as to the character of an exudate.

2. As a therapeutic measure in serous or serofibrinous pericarditis, (a) for the relief of the heart when embarrassed by the pressure of the fluid, in cases where the rapid increase of such an exudate acutely threatens the heart action; (b) for the removal of large accumulations which resist other therapeutic measures.

3. As an emergency procedure in compression of the heart by hemorrhage (heart tamponade), when incision of the pericardium must be postponed.

Paracentesis vs. Pericardiotomy.—Paracentesis, as compared with pericardiotomy, presents 2 striking disadvantages: (1) It exposes to the danger of accidental injury to the heart, coronary artery or vein, pleura, lung, and internal mammary artery. (2) The evacuation of the exudate is imperfect.

The choice between paracentesis and pericardiotomy as therapeutic measures is sometimes difficult. In suppurative processes there can be no uncertainty since these always demand pericardiotomy. In non-suppurative processes most surgeons follow a conservative policy and employ paracentesis, but some, notably von Waelzel and Brentano, recommend the radical procedure of pericardiotomy even in serous and serohemorrhagic exudates in view of the dangers of puncture and the efficient drainage obtained by pericardiotomy. But, pericardiotomy with drainage exposes to the danger of infection along the drainage tract, and this is more to be feared than a serious accidental injury as a result of puncture. Therefore, paracentesis is to be recommended in non-suppurative effusions in preference to pericardiotomy. Occasionally, non-suppurative processes may be subjected to pericardiotomy when repeated and rapid reaccumulation of the fluid occurs, or when the exudate is so thick that it prevents satisfactory aspiration, as in a serofibrinous effusion.

Site of Puncture.—Opinions differ widely as to the point of election in paracentesis of the pericardium. The favorite sites for puncture fall into 2 groups: those which are planned to avoid the pleura and those which disregard the pleura but are planned to avoid the heart. Under normal conditions the pleura is most reliably avoided in the region of the sixth and seventh cartilages of the left side close to the sternum. But, since the position of the anterior edge of the pleura is somewhat variable, the rules laid down for extrapleural puncture sometimes prove fallacious. On the other hand, cardiac injury is best avoided by puncture at a point situated somewhat internal to the lower part of the left limit of pericardial dulness. Curschmann advocates this site in preference to one in the immediate vicinity of the cardiac margin or apex (Dieulafoy), because the effusion is very frequently associated with an enlarged heart, in which case the heart may extend beyond the apparent position of the apex. The disadvantage of the outer site is that the pleural cavity may be entered, a feature which is especially disadvantageous in the presence of suppurative pericarditis, but penetration of the pleural cavity is not a necessary complication, because the pleural edges are separated by the distended pericardium and not infrequently the pleural layers are agglutinated to a considerable degree by adhesions, causing obliteration of the anterior part of the pleural sac.

The following sites are the most suitable for paracentesis of the pericardium:

(1) A point slightly internal to the left limit of dullness, in the fifth or sixth intercostal space.

(2) A point in the angle formed by the base of the xyphoid process and the seventh left cartilage at its insertion. The choice between these 2 sites must depend upon individual indications. In small serous accumulations, which demand puncture only in rare cases, the costoxyphoid angle should be the choice. In large non-suppurative effusions the outer site should be selected. If a purulent pericarditis is suspected, the operator must bear in mind that the inner site involves greater danger of injury to the heart, while the outer involves the danger of injury to the pleura with the possibility of infection of the pleural cavity.

But in the presence of a large effusion risk in either position is slight, and is probably less if the puncture is made at the outer site, near the left border of dullness, than in the costoxyphoid angle.

Of the numerous other sites that have been advocated the following may be mentioned:

(1) Left side close to the sternum in the fifth or sixth space.

(2) Fifth left space about 6 cm. from the margin of the sternum. The fourth space has also been recommended.

(3) Median line immediately below the tip of the xyphoid.

(4) Through the posterior thoracic wall. Curschmann suggests this method of intervention in those cases where the lower left pulmonary lobe is compressed by the distended percardium.

(5) The right side close to the sternum in the sixth or fifth space. The sixth right intercostal space is strongly recommended by Gras (1910) as the most reliable site for paracentesis in moderate and extensive effusions. His choice is based upon experimentation on the cadaver with pericardial injections. The needle is inserted close to the sternum and directed toward the left axilla. He asserts that the pleura is almost certain to escape injury, while the pericardium is opened where there is a copious effusion and at the level of the lower cardiac margin. When the sixth right intercostal space is not available, Gras advises that the fifth space be used. Although perforation of the pleura is possible, he asserts that it is not a common accident.

Technic of Paracentesis Pericardii.—Paracentesis should be performed under strict aseptic precautions. The puncture is usually made with the patient in the semirecumbent position. An aspirating needle or capillary trocar is used. It is advisable to make a small incision through the skin under local anesthesia, to ensure smooth introduction of the needle or trocar, and to guide the needle cautiously inward, the operator's hand or fingers resting upon the thoracic wall. The patient is instructed to exhale so that the pulmonary margins may become retracted, and the needle or trocar is slowly pushed inward, the direction being modified according to the site of puncture. When the outer margin of dulness is selected for the puncture, the needle is directed inward and somewhat downward. When the puncture is made at the sternal border, the needle or trocar is directed a trifle upward. A resistance is felt when the pericardial wall is encountered, and the progress of the needle must be stopped as soon as that resistance ceases. When the point of the instrument has penetrated into the pericardial sac, it should be lowered or, if a trocar has been used, the cannula should be withdrawn. If the point impinges upon the heart, the movements of that organ will be imparted to the instrument.

Although the technic of paracentesis is simple, puncture has often proved unsuccessful. A dry tap may result from the needle becoming blocked with fibrin or with tissue that has been penetrated during its introduction. The possibilities of injury to the heart, internal mammary artery, pleura and lung have been discussed. But it must be emphasized that serious accidents have occurred so infrequently that there should be no hesitancy in performing pericardiocentesis when the operation is positively indicated.

If a suppurative pericarditis is suspected, diagnostic punctures should not be made repeatedly; when several attempts prove unsuccessful, puncture should be abandoned in favor of pericardiotomy.

In a *therapeutic puncture* of the pericardium aspiration of the fluid must be very gradual in order to allow the heart to accommodate itself to the changed relations. A larger cannula is required than in an exploratory puncture. Evacuation is best accomplished with the trocar connected to an aspirator, such as the Potain or Dieulafoy. Special care must be exercised as the fluid diminishes to guard against aspirating the heart itself. A thickened serofibrinous exudate is very imperfectly emptied by this method.

Pericardiotomy

Indications.—Pericardiotomy, or incision of the pericardium, is indicated for the evacuation of a purulent exudate; for the removal of a foreign body and for exploration in doubtful cases of heart injury. Of necessity, the pericardium must be opened in any operation which exposes the heart or first portion of the great vessels, as in cardiorrhaphy or Trendelenburg's operation for pulmonary embolus, but under such conditions the incision of the pericardium is merely an incident of the operation, whereas in "pericardiotomy," as the term is used in this chapter, the object of the operation is attained by opening the pericardium.

Methods.—The methods of pericardiotomy may be divided for convenience into 2 groups:

1. Procedures which reach the pericardium through the thoracic wall.
2. Procedures which enter from below the costal arch, the epigastric route.

The first method of procedure includes:

Resection of the sixth cartilage, as recommended by Kocher, Axhausen and Pels-Leusden.

Resection of the fifth cartilage, Gussenbauer and Ollier.

Resection of fifth and sixth cartilages, Delmore and Mignon.

The second method of procedure has been accorded the preference by Larrey, Mintz, L. Rehn and Allingham. The approach is in part or entirely from below the costal arch and is both extrapleural and extraperitoneal.

Pericardiotomy for the Evacuation of a Purulent Exudate.—In the treatment of suppurative pericarditis the method of pericardiotomy to be efficient must provide for satisfactory drainage, and be sufficiently simple to be rapidly performed, under local anesthesia, if necessary. Adequate drainage is the essential feature, and upon this must depend to a large extent the choice of method. In the interest of good drainage it is important, first, to open the pericardium at its lowest point and, second, to provide such an opening as will ensure ready egress for accumulations in both the right and left spaces of the pericardial sac. Local anesthesia is frequently imperative because the heart is apt to be dilated and insufficient as a result of endocarditis and myocarditis. It is necessary that the work be done with the least possible associated injury. It is not sufficient to avoid wounding the heart; if possible, the heart should not be touched. Further, thorough anesthetization of the pericardium is advisable on the basis of significant experimental work, which we will briefly summarize.

Serious disturbances of the heart action have been noted repeatedly to result from irritation of the pericardium. Heitler's observations on dogs showed that irregularity of the heart follows mechanical or electrical stimulation of the pericardium. D'Agata (1912) in animal experiments found that a sudden drop in the blood-pressure occurred as a result of grasping and incising the pericardium. These phenomena are presumably reflex in character; they help to explain analogous clinical observations. Thus, Harrigan reported temporary arrest of the heart upon incision of the pericardium in a case of suppurative pericarditis.

Heitler and D'Agata found in their experiments that preliminary cocainization of the parietal layer of the pericardium prevented the occurrence of irregularity of the heart and the lowering of the blood-pressure. Heitler recommended that before an incision is made in the pericardium, it should be anesthetized by means of a 10 per cent. solution of cocain applied to its surface. Presumably novocain by injection could be substituted to advantage in man.

The 2 methods most appropriate for drainage in suppurative pericarditis will be described in detail.

1. Resection of the sixth costal cartilage (Kocher).
2. Resection of the seventh, or sixth and seventh costal cartilages (Rehn).

RESECTION OF SIXTH CARTILAGE.—This method affords adequate drainage at a dependent part of the sac, is simple and quick of execution, may be performed readily under local anesthesia, and the exposure may be extended easily in any direction. It appears to me the best method for general use.

With the patient in a semirecumbent position, an incision is made in the course of the sixth cartilage and rib, passing from the midline obliquely outward. The perichondrium is incised in the direction of the wound and separated. The cartilage is then severed close to the sternum and lifted, the perichondrium being separated from its posterior surface. The cartilage is broken at its junction with the rib and removed. The internal mammary artery should be divided between ligatures when exposed. The triangularis sterni is then split. An effort should be made to identify the anterior edge of the underlying pleura, which should be pushed outward. The pericardium is thus exposed. It should be grasped and lifted with two pairs of toothed forceps and incised. (The importance of anesthetizing the pericardium has been emphasized above.) The pericardial incision is extended with blunt-pointed scissors. The pus should be allowed to escape slowly. A finger is then introduced to break up adhesions and to evacuate walled-off accumulations of pus. Should the access be too small to allow separation of adhesions or for adequate drainage, the opening may be enlarged in an appropriate direction by resection of part of the sternum, excision of part of the sixth rib, or removal of the fifth or the seventh costal cartilages. Residual fluid should be removed by aspiration, as in abdominal operations, and sponging or wiping of the serous surfaces should be reduced to a minimum. Clots of fibrin should be extracted with forceps. Irrigation with sterile salt solution has been used for the removal of clots of fibrin, but is not to be recommended. The use of antiseptic fluids is contra-indicated. In closing the wound it is advisable, especially if the pericardium is considerably separated from the sternum, to suture it to the skin. This not only facilitates drainage but "diminishes the risk of contamination of the anterior mediastinum" (Eliot).

Drainage is favored by the movements of the heart which, in the absence of adhesions, tend to force out any accumulated pus (Eliot). The kind of drain which should be used is a detail which demands some discussion. The choice lies between a rubber tube and soft drain. Tubes afford the most satisfactory drainage and may be sutured to the soft parts so that they are not readily displaced. But if the tube should come into contact with the heart it is likely to interfere with the cardiac action, as occurred in a case operated upon by Riedel. Rehn recommends 2 rubber tubes, 1 passing to the right side and 1 to the left to drain both pockets. Eliot, Riedel and others favor soft drains. A general rule cannot be made; the mode of drainage must be such as to fit the individual case.

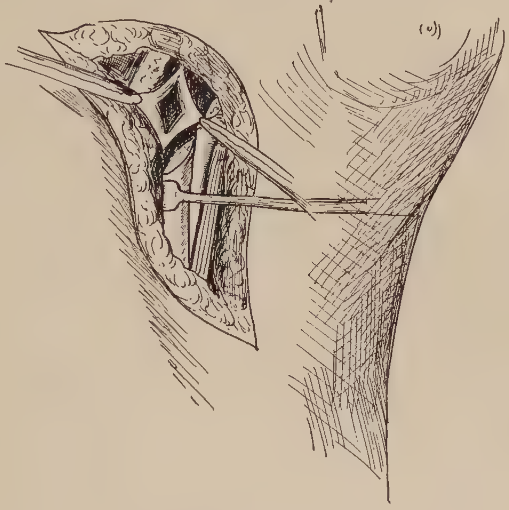

FIG. 6.—PERICARDIOTOMY OF REHN (after Küttner).

The sitting position should be enforced in the after-treatment as most favorable for drainage. The wound heals, as a rule, without a persistent sinus and "after healing is complete, insufficient or irregular heart action is the marked exception, neither is there any indication of cardiac displacement" (Eliot).

RESECTION OF THE SEVENTH, OR SIXTH AND SEVENTH COSTAL CARTILAGES.—A curved incision of about 6 cm. is made along the lower margin of the seventh left cartilage to the base of the ensiform process, across which the incision is continued transversely. The incision is deepened and the seventh costal cartilage divided. The internal mammary artery is preserved. Detaching the soft parts, the finger is passed under the sternum, between the lower portions of the triangularis sterni muscle and the sternal portions of the diaphragm. A useful guide is afforded by the inferior sternopericardial ligament.

A piece of the sternum and the seventh costal cartilage are removed, followed by resection of the sixth costal cartilage, if necessary. The pericardium is readily reached without opening the pleura. The more distended the pericardium, the easier the operation. (Description after Küttner.)

Results.—The results of pericardiotomy are necessarily modified by the gravity of the fundamental disease, but striking cures have followed operation in apparently hopeless cases of severe infection. The operation is, therefore, justifiable as an emergency procedure, even in desperate cases. The percentage of recoveries, as calculated from reported cases by Venus (1908), amounts to 55 per cent. Of 51 cases of pericardiotomy for suppurative pericarditis, collected by Porter (1900), 20 recovered and 31 died, a mortality of 60.5 per cent.

Tuberculous Pericarditis

Tuberculous pericarditis is usually associated with other tuberculous lesions, especially in the lungs, pleura or mediastinal lymph-nodes. There is, as a rule, considerable thickening of both layers of the pericardium. In early stages tubercles are found beneath the surface, fresh exudate of fibrin on the surface, but little or no fluid in the sac. Later there may develop an extensive serofibrinous, hemorrhagic or purulent exudate.

The tuberculous nature of the process is suggested by evidence of tuberculosis elsewhere, by bloody fluid on paracentesis, and by appropriate tests of the fluid aspirated.

Operative Procedures.—The operative procedures which may be considered are: 1. Aspiration; 2. pericardiotomy with drainage; 3. pericardiotomy, evacuation of the exudate and suture of the wound without drainage. The choice must depend upon the character and extent of the exudate, severity of the symptoms and condition of the patient. Moreover, it must be borne in mind that drainage will lead to mixed infection, which is to be avoided, if possible, as in tuberculous processes elsewhere. As a rule, purulent exudates are treated by pericardiotomy and drainage, other exudates by paracentesis, or, if this is unsuccessful, by reason of incomplete evacuation or rapid recurrence, by pericardiotomy followed by evacuation of the exudate and closure of the wound without drainage, as in tuberculous peritonitis.

As an example of tuberculosis of the pericardium treated by incision and drainage, a case reported by Gibson may be cited. The patient was a male negro, aged 26. For 2 months he had suffered from cough with slight expectoration; subsequently dyspnea developed, so marked in character that he could not lie down. The heart percussed 1½ in. to the right of the sternum and 6 in. to the left; the sounds were of poor quality and indistinct. The pericardium was aspirated and 18 ounces of opaque, yellowish fluid obtained. Improvement in the patient's condition was not marked and pericardiotomy was performed. The greatly distended pericardium was opened and the pus evacuated. It was estimated that the sac contained as much as 3 quarts. The pericardial edges were sutured to the soft parts, and a rubber drainage tube was passed into each lateral cul-de-sac. Subsequent drainage was profuse. The result, in respect to the pericardial lesion, was satisfactory.

Pericardiotomy without Drainage.—Jacob has recently recommended pericardiotomy without drainage in the treatment of tuberculous pericarditis. He reports 2 favorable experiences in cases with serous exudate. A flap with external base is employed. The cartilages of the fifth and sixth ribs are resected in their entire extent, the triangularis sterni muscle detached, the internal mammary vessels drawn aside and the pericardium exposed. Jacob recommends removal of the costal cartilages in order to afford a safeguard against disturbances due to subsequent pericardial adhesions. This is practically a prophylactic cardiolysis. After the exudate has been evacuated, the wound in the pericardium is not sutured, thus permitting drainage into the surrounding tissue. The remainder of the wound is carefully closed with sutures.

ADHERENT PERICARDIUM

As a result of pericarditis, the pericardial sac may become obliterated to a variable degree by the welding together of its 2 layers through more or less solid adhesions. Moreover, as a result of mediastinitis or pleurisy, firm adhesions may be formed between the pericardium and adjacent structures. In consequence of such adhesions the heart action is restricted. Under these conditions the neighboring structures, but especially the thoracic wall, oppose each cardiac contraction and the heart is required to do much extra work in overcoming this resistance. The condition is characterized clinically by a more or less marked systolic retraction of the chest wall overlying the heart, with a proportionate diastolic resiliency.

Prophylaxis.—Although various procedures have been suggested to limit the production of adhesions, no efficient method has been demonstrated. Rehn found in animal experiments that the introduction of iodipin into the pericardium served to prevent or lessen the formation of intrapericardial adhesions. Alexander suggested for the same purpose insufflation of atmospheric air or nitrogen gas, after the fluid has been evacuated by puncture. Wenckbach likewise advocated the introduction of air to shorten the course of exudative pericarditis. None of these procedures can be recommended.

Cardiolysis (Pericardiolysis; Pericardial Thoracolysis).—Cardiolysis or extensive resection of costal segments was devised by Brauer for the purpose of removing the ribs which imprison the heart and interfere with the cardiac systole. The rigid bony wall of the thorax is thus replaced by a soft, elastic covering which is easily moved by the heart and part of the cardiac power which previously had been wasted in overcoming the resistance of the thoracic wall is conserved. The removal of the bony framework of the chest also permits the heart to drop back into the thorax, thus relaxing the lateral or posterior adhesions which may be present.

TECHNIC OF CARDIOLYSIS—BRAUER'S OPERATION.—The operation can be performed rapidly even under local anesthesia, but general anesthesia is to be preferred. A flap is formed on the left side over the fourth, fifth and sixth ribs, the base of the flap lying in the axillary line and the free edge at the sternal margin. The soft parts, including skin and muscle, are turned back, followed by subperiosteal removal of the exposed portions of the fourth, fifth and sixth ribs and their costal cartilages, the lateral boundary of each resected segment lying slightly outside the nipple line, while the mesial boundary is close to the sternum. The sternum itself is left intact. The periosteum, which has been detached by the incision along the middle of the rib, is ablated after removal of the ribs, in so far as this can be done without endangering the pleura. Removal of the whole periosteum was formerly considered imperative to prevent new formation of bone; while advantageous, it is not easy, for the posterior costal periosteum is so closely connected with the pleura as to involve the risk of a pleural injury. Moreover, as Koenig emphasizes, there is relatively little tendency to new formation of bone in these cases. After careful hemostasis, a drain is inserted through an opening at the base of the flap, and the wound is closed with sutures. The drain may be removed at the end of 24 hours (description after Küttner).

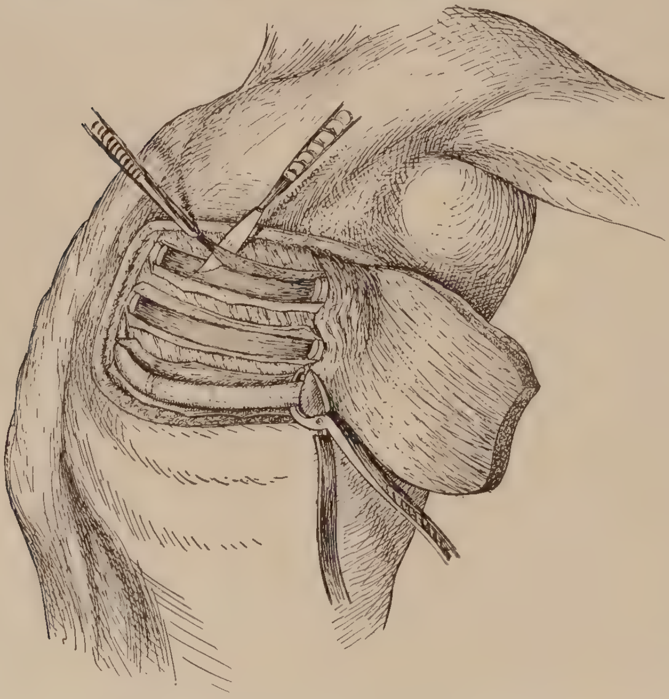

FIG. 7.—BRAUER'S CARDIOLYSIS (after Küttner).

RESULTS.—Delagénière has analysed 38 reported cases of cardiolysis. One patient died soon after the operation, 6 were not improved, and in 31 the results were good. In some of the published cases improvement was extremely marked. Thus, Küttner reports that 2 bedridden patients were restored to their full working capacity. Kolb points out that the operation cannot lead to an absolute cure; that the myocarditis persists and is of the greatest importance in the ultimate result. Kolb endorses the view of Venus, that Brauer's cardiolysis is a life-saving operation, which is destined to play a prominent part in the treatment of chronic adhesive mediastinopericarditis.

Delorme considers that Brauer's cardiolysis is beneficial only in cases presenting adhesions between the pericardium and the anterior thoracic wall. In the absence of such adhesions and the presence of adhesions between the 2 pericardial layers, that is, cardiopericardial adhesions, he recommends excision of a portion of the anterior wall of the pericardium.

Delagénière's Operation.—Delagénière advocates a more extensive operation than Brauer so as to liberate the entire anterior portion of the pericardium. He recommends his operation especially for those cases in which valvular lesions are present.

TECHNIC.—A large flap is cut with a left vertical hinge. The incision begins at the lower border of the chondrosternal articulation of the first left rib and passes obliquely across the sternum to the upper border of the second right chondrosternal articulation; it then passes downward along the right margin of the sternum, describing a curve with concavity inward, and terminates 2 cm. from the right margin of the sternum at a point on a level with the base of the xyphoid process. The incision is then carried horizontally to the left, passing across the base of the xyphoid process, stopping 6 to 8 cm. from the left sternal margin. The soft parts are detached as a flap, which is raised and turned to the left, thus exposing the entire portion of the bony framework of the thoracic wall which is destined for removal. Resection of the sternochondrocostal framework is made, at first following the line at the lower cutaneous incision, then the line on the left side, then the upper line, and finally the right lateral line. The subjacent parts are cautiously detached, guarding against injury to the internal mammary artery. The skin flap is replaced and sutured without drainage. The violently throbbing heart under the flap necessitates a rather resistant dressing so as to support the organ and allow it to adapt itself to its altered conditions. Delagénière performed this operation upon a woman 28 years of age with a satisfactory outcome.

WOUNDS OF THE PERICARDIUM

Wounds of the pericardium are usually, although not invariably, complicated by wounds of other important structures. Complications consist chiefly of injury to the heart, coronary artery, pleura, lung, the large vessels of the thorax and diaphragm.

Isolated injury of the pericardium has been observed most often in cases of oblique perforation in the lower half of the sac. Fischer collected 51 cases of isolated injury to the pericardium through stab, incised or gunshot wounds, or as the result of indirect violence (Tillman). According to the statistics of Loison (1899), the proportion of pericardial wounds, without heart wounds, amounts to 66 per cent. in pin or needle wounds; 11.1 per cent. in stab wounds; 12.2 per cent. in gunshot wounds. The diagnosis of pericardial injury is positive when the presence of blood or air in the sac (hemo- or pneumopericardium) can be demonstrated. Clinically a wound of the pericardium cannot be differentiated from one involving the heart. The outcome of these cases depends largely upon the associated injuries and subsequent complications. The operative treatment is discussed under wounds of the heart.

Illustrative Cases.—An illustrative case was reported by Lejars (1909). The patient, a woman, stabbed herself in the cardiac region with a dagger, and was admitted to the hospital several hours after the injury with the symptoms of intrathoracic hemorrhage. The wound was in the second left intercostal space. The thorax was opened and a large amount of blood escaped from the left pleural cavity. A wound in the middle lobe of the lung was closed and the hemorrhage stopped. A hole 2 cm. in size was then discovered in the pericardium from which blood exuded. The operator incised the pericardium and evacuated the blood. The heart was found to be intact. The pericardium and pleura were sutured with catgut, and the wound in the thorax was closed without drainage. Healing by first intention followed, and the patient made a perfect recovery.

A cured case of stab wound of the pericardium and the right pleura was recently reported by Fowelin. The wound, which had been inflicted by the patient with a shoemaker's knife in an attempt at suicide, lay transversely in the uppermost portion of the epigastric angle and measured about 4 cm. Treatment consisted in resection of a portion of the sternum and the cartilages of the fifth, sixth and seventh ribs, followed by accurate suture of the pleura and the pericardium.

FOREIGN BODIES IN THE PERICARDIUM

The presence of a foreign body in the pericardium is a very common complication of pericardial wounds (1:5, according to Salomoni), and even more frequent in association with wounds of the heart. Bullets, needles, pins, and fragments of weapons are the foreign bodies usually found. Zesas' compilation of cases of foreign bodies in the human heart (1910) contains 19 observations concerning the pericardium.

In the case of a small body such as a bullet there is the possibility of it becoming encysted in the pericardial sac, sometimes without interfering with the general health of the patient. But coincidently with the entrance of a foreign body infection is frequently introduced with resulting suppurative pericarditis. Plastic pericarditis is a very common sequel to pericardial wounds, but complete adhesions rarely follow. The treatment of foreign bodies in the pericardium is the same as that of foreign bodies in the heart, under which it will be discussed.

Illustrative Cases.—In Soverini's case a needle which had been swallowed was found in the pericardium after the patient's death two days later; the right ventricle, two branches of the right coronary artery and two veins were wounded.

In a case quoted by Buist the gold plate of an artificial denture with 2 teeth had been swallowed, and after the patient's death, on the fifth day, the pericardium was found to be distended with pus; the teeth were imbedded in the esophagus and had ulcerated through into the pericardium.

In a case reported by Schwarzwald, a man, 43 years of age, died suddenly and the cause of death was found to be hemopericardium. The intrapericardial hemorrhage came from 2 small gaps in the pulmonary artery and 2 slits in the pericardium. The wounds were explained by the presence of several steel needles, which apparently had entered the body through the skin at distant points.

In a case which was presented before the Madrid Medico-Surgical Society by Rodriguez y Rodriguez, the foreign body in the pericardium was a piece of glass, 4 cm. long and 1 cm. wide. Its extraction was followed by suture of the pericardium and recovery.

In a case reported by Fink a bullet had penetrated the thoracic wall and pierced the left ventricle; it was found lying free in the pericardium. The patient died the day after the accident.

In Gallard's case, quoted by Zésas, a needle had entered the thorax. It was found projecting about 12 millimeters into the pericardium and had wounded the left ventricle. The patient died one month later from collapse.

EXPERIMENTAL PERICARDIECTOMY

Animal experiments were recently performed by Mazzone (1912) for the purpose of demonstrating whether life is possible after total or partial pericardiectomy, such as may be required in the extirpation of malignant tumors of the thoracic wall. The experiments were 7 in number. The animals survived extensive as well as partial removal of the pericardium. Parlavecchio, in dogs, and Amerio, in rabbits, also demonstrated that extensive and approximately total extirpations of the pericardium are consistent with life, but found that the operation was invariably followed by hypertrophy of the left ventricle and general emaciation. It is a noteworthy fact that the extensive extirpations, with removal of the entire anterior and left pericardial wall, are more readily tolerated than partial excisions, which leave troublesome adhesions between the pericardium and the heart. After extensive extirpations, the pericardial cavity is converted into an appendage of the left pleural cavity.

Concerning the therapeutic applicability of extirpation of the pericardium, Parlavecchio believes, on the basis of his successful experiments upon dogs, that this procedure may enter into consideration in tumors of the thorax as well as in certain cases of chronic suppurative pericarditis. The literature contains a series of observations on congenital defects of the pericardium which illustrate the compatibility of life with the absence of this structure.

In regard to the technic of pericardiectomy in the human subject, Mazzone states that the exposure of the cardiac region should be free and no attempt should be made to avoid opening the left pleural cavity. It is probably better to sacrifice the left phrenic nerve than to detach it from the pericardium or to attempt the preservation of the vertical strip of pericardium in relation with which the nerve lies.

The covering of large defects in the pericardium by means of flaps taken from the fascia lata was recently suggested by Henschen on the basis of animal experiments.

OPERATIONS UPON THE HEART

WOUNDS OF THE HEART

Wounds of the heart are caused most frequently by stab wounds and gunshot wounds. The heart wall may be injured in part or the whole of its thickness. Associated lesions are frequently present, especially wounds of the pleura, lung, coronary artery and internal mammary artery; less often the diaphragm, peritoneal cavity, abdominal viscera and mediastinal structures are involved. The pericardium is almost of necessity opened, though in rare cases it is said to have been pushed inward but not penetrated by the weapon causing the wound of the heart.

Hemorrhage from a heart wound is almost always free, but varies with the size and obliquity of the wound, the degree of penetration, and the part of the heart injured; thus, a wound of the thick walled left ventricle bleeds relatively less than one of the right ventricle or auricles. The blood may accumulate in and distend the pericardial sac (hemopericardium) or it may enter the pleural cavity if the pericardial wound is such as to afford free communication between the 2 cavities. When the blood accumulates within the pericardial sac, intrapericardial tension occurs and as a result the heart action becomes impeded. This is known as heart tamponade. The degree of the cardiac disturbance is dependent upon the amount and rapidity of the hemorrhage. The intrapericardial tension affects primarily the thin-walled auricles and unresisting veins, with the result that the flow of blood is retarded; secondarily it influences the ventricular contractions, which are impeded and ultimately arrested.

The symptoms of a wound of the heart are dependent upon shock, hemorrhage and associated lesions. Shock is usually marked. Hemorrhage may cause: 1. Hemothorax, with symptoms of internal hemorrhage and signs of fluid in the pleural cavity,

2. Hemopericardium, with the objective signs of dilatation of the pericardial sac and more or less marked symptoms of heart tamponade, which is evidenced by dyspnea, cyanosis, small, weak and irregular, or even imperceptible pulse, enlargement of the cardiac dulness and distant feeble heart sounds.

Indications for Operative Interference in Heart Wounds.[1]—The rationality of immediate surgical treatment for wounds of the heart has been thoroughly established by 15 years of relatively good and constantly improving results. Even in suspected wounds of the heart, when the diagnosis is probable but not positive, exploratory operation is an approved procedure, as has been emphasized by E. Hesse, Foederl, and others, for the following reasons: *First,* there is no typical clinical picture whereby a wounded heart can always be diagnosed, especially in the first few hours after injury. The classical syndrome, "heart tamponade," due to intrapericardial pressure, is more often absent than present (Borchardt); physical signs in the cardiac region, such as abnormal sounds and increased dulness, are frequently inconclusive; the position and direction of the surface wound are not always convincing; while the suggestive symptoms of internal hemorrhage, hemothorax or hemopneumothorax may originate entirely in thoracic lesions other than a heart injury. Evidence of the uncertainty of the diagnosis is gained by an analysis of 21 cases which were the basis of E. Hesse's report; heart tamponade was absent in 13; in only 11 of the 21 cases was the diagnosis certain, whereas in 4 it was probable and in 6 doubtful on account of the absence of all reliable signs. *Second,* it has been shown by statistics that the prognosis, by reason of hemorrhage and shock, becomes progressively worse as the interval between the trauma and the operation lengthens. Therefore, although delay in some cases will render the diagnosis certain, postponement of operation until dangerous symptoms make their appearance is not to be recommended. *Third,* the immediate results of non-operative treatment are very poor as compared with those obtained by operation (E. Hesse). Moreover, although some heart wounds heal without surgical intervention, there is always danger of secondary hemorrhage from an unsutured wound, and the spontaneously healed heart wound (even a non-perforating wound) leaves a weak scar which may rupture or become the site of an aneurysm (Rehn). Loison, as early as 1899, collected 9 such cases.

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[1] Through the courtesy of the publishers of the *Annals of Surgery* much of the discussion of the technic of heart suture is reproduced from an article by the writer which appeared in that journal.

SUMMARY OF INDICATIONS.—The diagnosis of heart wounds is frequently uncertain, especially soon after the injury; the prognosis becomes progressively poorer with delay; the immediate and late results of operative treatment have been much better than the results of non-operative treatment. Immediate exploration is therefore indicated even when the diagnosis is in doubt and a heart wound is probable but not positive.

Technic of Operation.—PREPARATION.—Careful preparation of the operative field is essential, since many cases which have survived shock and hemorrhage have died later as the result of infection. The iodin method is the most reliable and the quickest method of preparation. The operative field, including the wound, is painted with 7 per cent. tincture of iodin, which is allowed to dry. Everything necessary for the operation should be in readiness before it is begun. The ordinary dissecting and bone instruments, curved intestinal needles threaded with fine silk, appropriate needle holder, rib retractors, sterile vaselin and an infusion apparatus are the essentials.

ANESTHESIA.—Experience indicates that anesthesia should consist in the sparing administration of a general anesthetic, preferably ether, when the patient shows signs of sensibility.

DIFFERENTIAL PRESSURE.—The indications for differential pressure are so striking as to induce its employment. Since the development of the Meltzer-Auer method it has become possible for every hospital to be provided with facilities for its use. Therefore, the applicability of differential pressure in operations for wounds of the heart will doubtless be thoroughly tested in the immediate future; consequently, this detail deserves careful consideration.

A majority of the cases of heart wounds are complicated by opening of the pleura (Borchardt); Sauerbruch puts the figure at 80 per cent. Even if not opened by the original wound, experience shows that the pleura is usually torn during the course of the operation. Pneumothorax with collapse of the lung is, therefore, likely to occur in every case. But the immediate dangers due to pneumothorax can be eliminated and the late dangers minimized by the use of differential pressure. Therefore, differential pressure permits a disregard of the pleura, and, consequently, expedites the operation by allowing a free transpleural exposure; moreover, it greatly diminishes the tendency to postoperative pleural infection, by allowing dilatation of the lung and consequent absence of pneumothorax following the operation (Sauerbruch). Other less important advantages of differential pressure are that it increases the oxygenation of the blood, renders the technic of the heart suture easier in that it lifts the heart and renders it more accessible, at the same time removing the annoying respiratory movements, and, finally, assists in the discovery of a wound of the lung so that it may be sutured (Sauerbruch and Haecker).

There are some considerations which indicate great care in the amount of pressure used during the first stages of the operation. Sauerbruch and Haecker found in animal experiments that at first a pneumothorax leads to a diminution of heart activity and lessens the bleeding from the heart. On the basis of these findings, Matas discourages the use of differential pressure until the heart has been sutured, because he considers that a collapsed lung may be an advantage by diminishing the bleeding from the heart wound. But Sauerbruch and Haecker state that in their experiments continuation of the collapsed lung led to such depression of the heart as to render it necessary to dilate the lung in order to save the animal, and Sauerbruch believes that low pressure does not increase the bleeding. Therefore, although Matas's warning should be borne in mind, it seems probable that differential pressure, in view of its marked indications, may be used throughout with advantage, danger from increased hemorrhage being averted by a rapid exposure and rapid control of hemorrhage, pressure being reduced to a minimum until bleeding has been controlled. Possibly insufflation of oxygen will prove an advantage in this connection, since it can be used under much lower pressure than is necessary to give the same effects with air (Volhard, Tiegel). In operations for heart wounds differential pressure has been employed in one case by Friedrich and in 4 cases reported by Ranzi. As a result of his experiences, Ranzi expresses himself very positively in favor of its use.

EXPOSURE OF THE HEART.—The question of exposure of the heart is greatly simplified if it is recognized that an extrapleural cardiorrhaphy is rarely possible, and if dependence is placed upon differential pressure for controlling the dangers of pneumothorax. The principles of exposure by which almost all indications can be met most satisfactorily are the intercostal incision, the osteoplastic flap, and the extrapleural exploratory pericardiotomy.

The intercostal incision (Fig. 8), as Wilms states, affords free exposure of the heart, can be applied much more quickly than a flap operation, and causes less hemorrhage, while the resulting pneumothorax cannot be urged against the method since it is rarely possible to avoid its occurrence by other procedures.

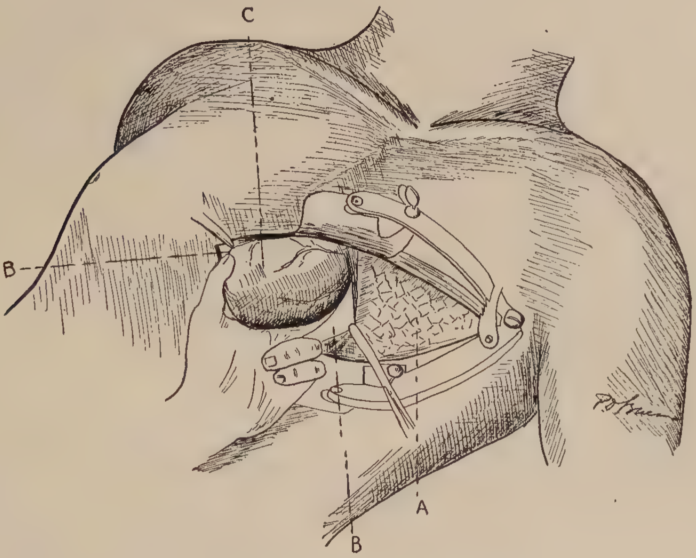

Fig. 8.—Intercostal Incision; Method of Lifting the Heart (Sauerbruch and Schumacher). A, Lung; B, pericardium; C, heart.

The intercostal incision should be elected when differential pressure is used, when pneumothorax is already present, or when the condition of the patient makes speed of primary importance. A long intercostal incision placed in the fourth space gives the best exposure, although other spaces may be used. The proper application of this incision necessitates opening the pleura freely; forcible retraction then gives considerable exposure. As in all methods, the internal mammary must be ligated above and below when exposed. The pericardium is opened in the same direction as the skin incision; if more space is desired, it may be obtained by cutting away part of the sternum and by section, near the sternum, of adjacent cartilages, with or without incision of the soft parts upward or downward. The method of closure is shown in Figure 10.

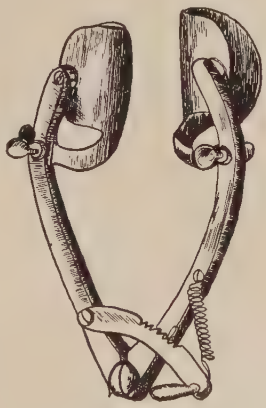

Fig. 9. — Retractor for Separating Ribs (Sauerbruch and Schumacher).

Although the preservation of the pleura is a distinct advantage, it should be aimed at only in selected cases, since the effort delays the operation and usually fails. The circumstances which warrant an effort toward an extrapleural operation are: differential pressure not available, pneumothorax not present, no wound of the pleura such as would render the effort useless, and relatively good condition of the patient, for when the condition is grave it is important to adopt the simplest and quickest method and to lose no time in attempts at elaborate extrapleural procedures.

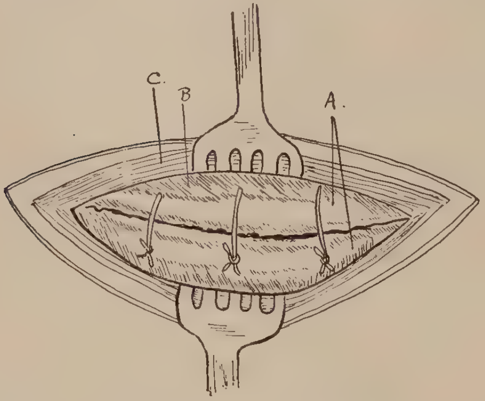

Fig. 10.—Pericostal Suture for the Closure of the Intercostal Incision. (Sauerbruch and Schumacher). A, Ribs; B, intercostal muscle; C, muscles of thorax.

Certain flap methods afford good exposure and offer the best prospects of preserving the pleura intact, when such an effort appears indicated. A flap with lateral base has proved the most satisfactory both in operations and experimentally on the cadaver. A flap as planned by Kocher (Figs. 11, 12) gives admirable exposure. An incision of about 10 cm. is made from the middle of the sternum along the sixth left costal cartilage, which is carefully resected after separating the perichondrium; the pleura is exposed and stripped outward. From the inner end of the incision a vertical incision is carried upward on the sternum as far as is indicated, even to the third rib; a third incision of about 8 cm. is carried horizontally outward. A flap of the fifth, fourth, and, if necessary, third cartilages is lifted, the pleura being separated and if possible left untorn. The cartilages are broken readily at the costochondral junction. In the event of a small wound being made in the pleura, an effort should be made to limit the entrance of air into the cavity by protecting the hole with gauze. The pleura is then carefully stripped outward to expose a greater surface of pericardium. The heart is exposed by making a triangular or rectangular pericardial flap. This method not only affords a good exposure, but also permits satisfactory primary or secondary drainage in a dependent part of the pericardium and the part uncovered by pleura. Yet for some cases it would carry the exposure unnecessarily low. Therefore, in high wounds a simpler and more suitable procedure may be used

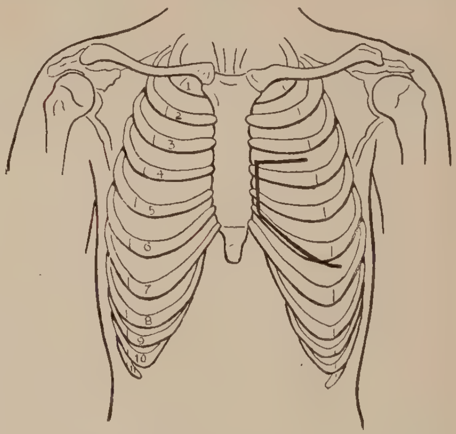

Fig. 11.—Exposure of the Heart (Kocher). Excision of 6th cartilage. Osteoplastic flap of 4th and 5th cartilages.

by omitting resection of the sixth cartilage and forming a flap (Fig. 13), appropriately placed with pedicle outward, of 2 or 3 cartilages, especially the fourth, fifth, and third. Additional space in the direction needed may be obtained by cutting away part of the sternum and by section or resection of adjacent cartilages.

In certain doubtful cases the primary incision may be designed for exploration. The original wound, if situated in the precordial region, may then be extended and deepened layer by layer, the edges of the original wound being excised. If it appears indicated, the incision may be utilized for carrying out one of the methods of exposure already mentioned or for an appropriate atypical exposure. If the original wound is not in the precordial region, in the absence of differential pressure, an extrapleural exploratory pericardiotomy may be used advantageously. For this the choice lies between resection of the sixth cartilage (Kocher) and pericardiotomy in the costoxiphoid angle (Rehn). Resection of the sixth cartilage is to be recommended. The technical details of these procedures have been described in the section on Pericardiotomy. By either of these methods the pericardium can be exposed quickly, under local anesthesia if necessary. If the pericardium is found to contain blood, the heart may be freely exposed by an osteoplastic flap.

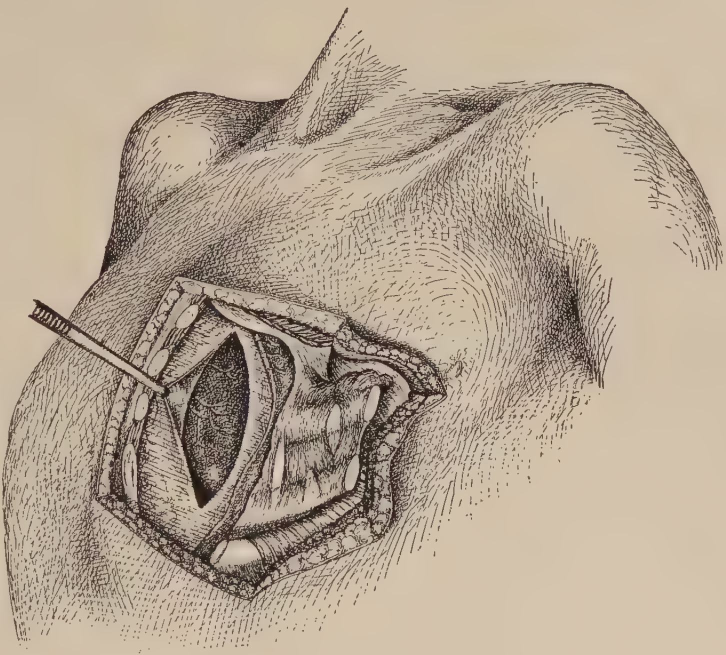
FIG. 12.—EXPOSURE OF HEART BY KOCHER'S PROCEDURE (Küttner).

For wounds involving the right region of the heart König suggests as the best procedure that of Marion, with the modifications of Wehr and Lorenz (Fig. 14). In the rare condition of a wound of the right side of the thorax with right pneumothorax, the exposure of the heart should be planned to avoid opening the left pleura, especially when differential pressure is not used. In Marion's method the left pleura is likely to be opened; therefore, if right pneumothorax is present, this procedure should not be considered in the absence of differential pressure. If differential pressure is not available, a modification of the procedure suggested by Rehn, which is described below, should prove appropriate. A sternocostal flap with base to the right should be employed, with secondary removal or retraction of the sternum and cartilages on the left of the incision to such an extent as is necessary for the proper exposure of the heart.

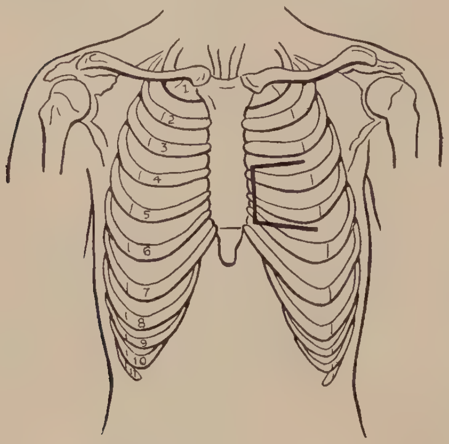

Fig. 13.—Exposure of the Heart by Osteoplastic Flap, Containing 4th and 5th Costal Cartilages. 6th cartilage cut across.

Rehn has recently recommended a method, referred to above, for exposing the heart without opening the pleura. An incision is made along the left costal arch and another from the inner end of this upward over the middle of the sternum. The pleura is pushed outward on each side by a finger inserted under the sternum. The sternum is then split obliquely upward to its left margin in the region of the third costal cartilage. The flap is forcibly drawn to the left, following division of the costal cartilages, if necessary, and transverse incision of the soft parts over the third intercostal space. An osteoplastic flap including part of the sternum is thus formed. Rehn also suggests a more elaborate procedure (Fig. 15), namely, bilateral incisions along the costal arch with median incision upward over the sternum; the sternum is bisected to the level of the third costal cartilage and there divided transversely; bilateral osteoplastic flaps are thus formed. The originator of the method claims for it greater security against injury to the pleura, but, as we have emphasized previously, the employment of differential pressure makes it unnecessary to use such elaborate methods.

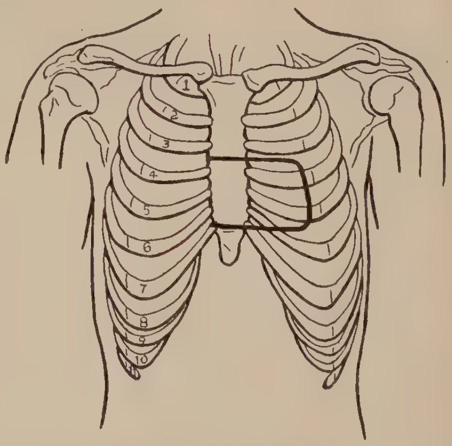

Fig. 14.—Exposure of the Heart by Osteoplastic Flap with Pedicle Internal, According to Marion, Wehr and Lorenz.

LOCATION OF THE WOUND.—After exposure of the heart, if any difficulty is encountered in locating the wound, the index and middle fingers of the left hand may be inserted posterior to the heart, the thumb being placed on its anterior surface, and it may then be lifted, turned, or drawn downward for inspection (Fig. 8) (Rehn). But if hemorrhage is excessive, the method suggested by Sauerbruch and Haecker (Figs. 16, 17) may be used advantageously. In this method the left hand is inserted so that the right auricle with its entering vessels lies between the third and fourth fingers, while the thumb and index finger grasp the lower portion of the heart and luxate it upward; this, they say, serves to bend the vessels and control bleeding, while at the same time the heart wound is rendered accessible. Rehn suggests controlling hemorrhage by compressing the inferior and even the superior vena cava with the fingers of the left hand.

HEART SUTURE.—For suturing the heart, both chromicized catgut and silk have been used. But the interrupted silk suture, well vaselined, has much to commend it, in that it offers a finer material, which causes the minimum of trauma, is well tolerated, allows the knots to be tied more securely, and is not loosened by subsequent softening of the suture material at the knots. In a case of wound of the left ventricle reported by Schoenborn catgut sutures were used and were found at autopsy, a few hours later, so loose that they probably would have given way.

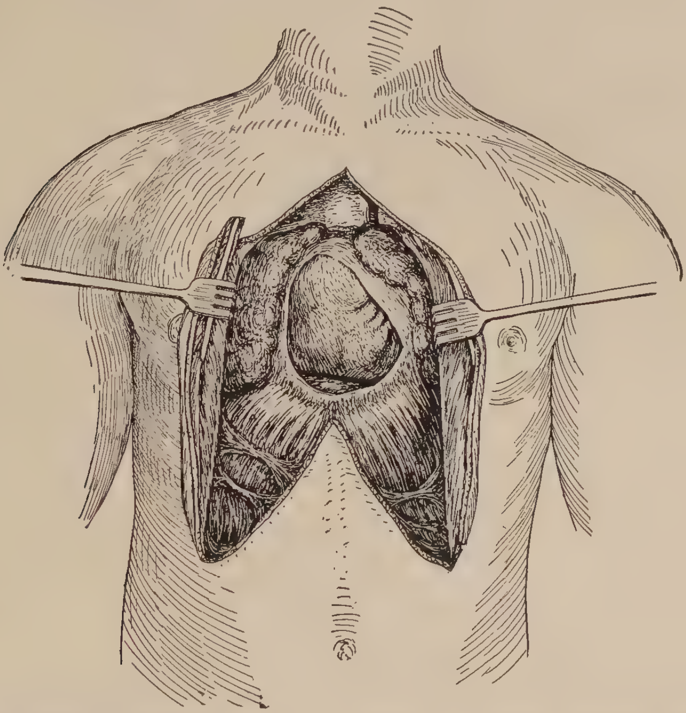

FIG. 15.—EXTRAPLEURAL EXPOSURE OF HEART ACCORDING TO REHN (Handbuch der Praktischen Chirurgie).

After the controlling stitch has been placed, it should not be difficult in most cases to insert the remaining stitches. In my case this was done quite easily by having the assistant draw on the first stitch with one hand and control the bleeding by pressure with a finger of the other hand; for each subsequent stitch this finger was momentarily lifted. It was found impossible to differentiate between systole and diastole in tying the sutures, and case reports show this to be a common experience. The suture should not penetrate the heart wall, yet reports indicate that in thin-walled portions of the heart it is impossible to determine accurately the depth of a suture. Occasionally, as in cases reported by Neumann and E. Hesse, cardiorrhaphy is unsuccessful on account of friability of the heart muscle and persistent cutting through of the sutures. In such an event the latter recommends cardiopericardioplasty.

For cessation of the heart action during operation, gentle massage is indicated. Injections of salt solution into the cavity of the left ventricle (Gütig) and camphor (F. Hesse) or adrenalin (Leichner) into the wall of the ventricle have been tried but without encouraging results.

After the heart has been repaired, a saline infusion should be begun and the lung should be inspected when an injury seems probable, because a neglected pulmonary injury may lead to a fatal outcome. Death in one of Heinrichsen's cases was due to a simultaneous injury of the lung which had been overlooked. The importance of this step is further emphasized by statistics, which indicate that the lung is injured in a large proportion of the cases; in 13 per cent. of stab wounds, according to Loison.

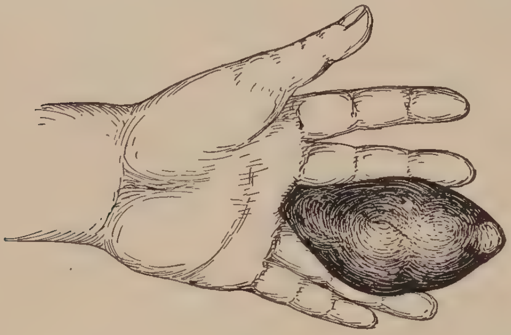

Fig. 16.

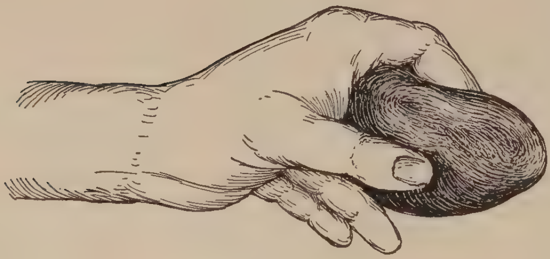

Fig. 17.

Figs. 16 and 17.—Method of Grasping Heart if Hemorrhage is Excessive (Sauerbruch and Haecker).

PERICARDIAL SUTURE.—The closure of the pericardial sac should be made with interrupted catgut sutures, because tension between the edges of the wound may occur not only at the time of the operation but later as a result of distention of the sac with serum; distribution of the strain among a number of stitches renders the suture more secure.

DRAINAGE.—The question of drainage is important, since a large proportion of cases are lost as a result of infection of the pericardial or pleural cavities. It is fair to assume that faulty judgment in the matter of drainage is often responsible.

There are strong arguments for and against pericardial drainage, which may be briefly considered: It is probable that a considerable postoperative exudation of serum is not infrequent after operations on the heart, as is evidenced by the cases of Magenau and Torre, which were not drained, and my case, in which no drain entered the pericardial sac. Should this serum be confined within the pericardial sac, the heart action may be impaired, as in the cases of Proust and Magenau, in which the heart action improved after liberating the fluid; should it accumulate in the soft parts outside of the pericardial sac, it would favor extensive suppuration. Hence an exit for this fluid would prove an advantage. If infection has been introduced by the original wound or during the operation, drainage will obviously be an advantage. If care is taken in the dressings, subsequent infection should not occur, since the discharge, although free, persists as a rule for only a few days. While dangerous accumulation of serum may be removed by puncture and aspiration, the procedure is not without danger, and the indications are not clear until serious symptoms have developed.

On the other hand, the irritation of a drain projecting into the sac might reasonably be supposed to favor excessive exudation, as occurred in the cases of Schoenmaker, Proust, Neugebauer and Renner, and the formation of adhesions, which militate against the best functional activity. That serious results may be due to adhesions is shown by Walther's case of stab wound of the right ventricle which was sutured. Three years and 8 months after operation death occurred as the result of cardiac insufficiency. At autopsy extensive cardiopericardial adhesions were found; the cicatrix appeared as a wide translucent area, and at this site the heart wall was very thin, though there was no aneurysm.

It is evident that drainage in each case must be decided by the individual indications. In some cases in which there is short exposure and little trauma, closure without drainage should be carried out; on the other hand, when the nature of the wound and the operation render infection probable, the drain should penetrate slightly into the sac. But in most cases, on the basis of the above reasoning, it appears safest to treat the detail of pericardial drainage as follows: First, to leave unsutured a small portion of the lowermost, or in an intercostal incision the innermost, part of the pericardial wound, so that in the event of a large accumulation of serum the fluid may exude through the opening, and, second, to provide a surface exit for the serum by inserting a drain down to but not into the pericardial sac. This method was efficient in my own case. A cigarette or rubber tissue drain should prove the most satisfactory. As suggested by case reports, any form of drain, such as gauze, which is likely to obstruct and not drain should be avoided. On the other hand, a rubber tube, while best for drainage, might communicate with the pleural cavity when this has been opened, especially in an intercostal incision, and cause a pneumothorax.

Drainage of the pleural cavity has been urged, notably by F. Hesse, on the theory that infection in the pleural cavity that has been opened is peculiarly prone to occur, not only as the result of the wound or ordinary operative infection, but as the result of air infection, since air is sucked in and expelled with every respiratory movement. Moreover, the pleural resistance is diminished by prolonged exposure to the air, operative traumatism, postoperative pneumothorax, and the persistence of blood or the accumulation of exudate in the cavity. Further, the pleura does not react to the same degree as the peritoneum in localizing inflammatory processes through adhesions.

Against drainage may be urged the resulting pneumothorax, which can be entirely eliminated by differential pressure when drainage is not used, and the danger of infection from without, as the result of the drainage. Infection in a drained case is difficult to prevent because the discharge in such cases is usually copious and prolonged (cf. cases of F. Hesse, 1909, Einar Key, and others).

Statistical analyses of reported cases do not aid as much as might be expected in deciding the question of drainage; conclusions based on the statistics are not convincing by reason of the numerous modifying factors in each case, such as associated lesions. Further, accurate statistics are impossible, because many unsuccessful cardiorrhaphies remain unpublished; moreover, complete details of published cases are often not given. Yet recent writers have been somewhat influenced by statistical studies. Thus, E. Hesse favors closure of the pleura and pericardium on the basis of his own experiences and the following statistical considerations:

Pericardium and pleura were closed in 30 cases, 21 (70 per cent.) recovered.
Pericardium and pleura drained in 43 cases, 25 (58 per cent.) recovered.
Pericardium closed, pleura drained in 25 cases, 10 (40 per cent.) recovered.
Pericardium closed, no statement as to pleura, in 15 cases, 10 recovered.
Pericardium drained, no statement as to pleura, in 8 cases, 4 recovered.

Hesse's personal cases in which the patient survived operation: both closed, 6 cases, 5 cures; both drained, 6 cases, 1 cure; pericardium closed, pleura drained, 3 cases, no cures.

On the other hand, although the statistical compilation of Rehn (1907) does not show the advantage of closure of the pleura, Rehn proclaimed himself against pleural drainage.

Tiegel argues that pleura and pericardium should be drained, and that the drainage of each cavity should be at its most posterior and dependent part. He suggests an ingenious device to accomplish this. The method, he states, enters into consideration only when the pleural cavity has been opened in the pericardiotomy and when there are no adhesions to interfere. A tube is passed from the opening in the posterior wall of the pericardial sac through the posterior part of the pleural cavity and through a punctured wound between the ribs to the surface of the back. At the point where it leaves the pleural cavity the tube is fenestrated. The outer end of the tube is provided with a valve to prevent the entrance of air. The method appears too complicated to be recommended.

It is my opinion that the pleural cavity should not be drained as a "prophylactic" step against possible infection unless there are very strong reasons for suspecting infection. In general, the accumulated blood should be removed entirely from the pleural cavity by aspiration and gentle sponging, avoiding, as far as possible, injury to the pleura. The pleural wounds should be carefully closed with distention of the lung if differential pressure is used. Evidences of pleural infection should be watched for, and, if necessary, drainage established later, as has been done in a number of cases. In exceptional cases, where exposure has been prolonged and when from the nature of the wound and its administration infection appears probable, the thorax should be drained, especially if differential pressure has not been used. The drainage should be made posteriorly just as in empyema; as emphasized by F. Hesse, anterior drainage can be of little use.

CLOSURE OF SUPERFICIAL WOUND.—Closure of the superficial parts of the wound is made with interrupted buried catgut sutures. If a flap operation has been performed, the flap is first carefully replaced. The skin is closed with interrupted sutures and a copious dressing applied.

Postoperative Care.—Quiet is the essential feature. For restlessness, morphin should be administered. Failure of the heart must be treated with appropriate but sparing cardiac stimulants. Saline solution should be administered by rectum.

It is essential that extreme care be taken during the dressings of the wound to avoid secondary infection through the drainage tract. Free serous discharge is the rule; therefore, frequent dressings are indicated. Under favorable conditions the drain can be removed about the fourth day.

In the after-care, pneumonia and other complications must be watched for and treated, but the most frequent and most dangerous complications are suppurative pericarditis and empyema. They must be borne in mind and treated by appropriate drainage as soon as recognized.

Results.—E. Hesse (1911) collected 219 cases of cardiorrhaphy with 116 deaths and 103 recoveries. He points out that this ratio gives a false impression of the percentage of cures, because numerous failures are doubtless not reported. He calls attention to the relatively small number of cases in the United States and England and the large number in Italy and Russia. The number of reported cases has increased rapidly in recent years. Statistical compilations of the cases of heart suture have been made by Peck, 1909, and Pool, 1912. These compilations supplement one another. The aggregate of cases was 236.

Conclusions.—1. The treatment of heart wounds should be surgical. Even in suspected wounds of the heart, when the diagnosis is probable but not positive, exploration should be performed.

2. Careful preparation of the field of operation is essential, since many fatal results have been due to sepsis.

3. Light general anesthesia, preferably ether, should be administered when there are signs of sensibility.

4. It is important to recognize that in a large proportion of heart wounds the pleura is opened and that an extrapleural cardiorrhaphy is rarely possible.

5. Differential pressure offers marked advantages chiefly by eliminating the immediate and minimizing the late dangers due to pneumothorax. Its use

expedites the operation by allowing a free transpleural exposure. But prior to the control of bleeding from the heart wound, positive pressure should be used with great care because it may increase hemorrhage.

6. (*a*) A transpleural exposure with long intercostal incision is ordinarily the best because it affords free exposure of the heart, can be applied much more quickly than other procedures, and causes less hemorrhage. This exposure should be employed when differential pressure is used, when speed is important, or when pneumothorax is present.

(*b*) An effort to do an extrapleural operation is warranted in exceptional cases. The indications are: differential pressure not available, pneumothorax not present, no injury to the pleura such as would render the effort useless, adequate assistance, and relatively good condition of the patient. Under these conditions, a flap with pedicle outward is advisable.

(*c*) In some cases in which the diagnosis is in doubt, extrapleural exploratory pericardiotomy may be performed by resection of the sixth costal cartilage, as in the primary incision of Kocher's flap operation.

(*d*) Atypical procedures are at times indicated.

7. Fine vaselined silk on a curved intestinal needle is the best material for heart suture.

8. The pericardium should be closed with interrupted catgut sutures.

9. Pericardial drainage may be dispensed with in some cases when there is short exposure and little trauma. A drain should enter the pericardium to a slight extent when the nature of the wound renders infection probable. But in most cases it is best to insert a drain down to but not into the pericardial wound, a small part of which should be left unsutured. In this way an exit is provided for the large accumulation of serum which is likely to occur, and irritation of the pericardium by the presence of a drain is avoided.

10. Pleural drainage is a prophylactic step which is often unnecessary and likely to be harmful. Unless there is a strong probability of infection, it is better to delay drainage until infection has occurred and then do a secondary thoracotomy.

Illustrative Case.—A brief review of a case of heart suture which came under the observation of the writer will emphasize practical details of the operation and postoperative course.

In July, 1911, a young man, 24 years old, was brought to the New York Hospital about 30 minutes after he had attempted to commit suicide by stabbing himself with a knife over the heart. He was in a condition of profound shock; the pulse was imperceptible in the radial arteries; the heart sounds were audible but distant and muffled; percussion indicated an increase in the area of cardiac dulness. There was a wound about ½ in. in length in the fourth intercostal space just mesial to the nipple. A probe inserted a short distance showed that the direction of the wound was somewhat upward and inward. There was very little external hemorrhage. Operation was begun less than an hour after the accident.

Light ether anesthesia was administered. The wound was extended along the upper border of the fifth rib toward the sternum, crossing and dividing the fifth cartilage near its insertion. The stab wound entered the pleura, and in exposing the pericardium the pleural opening was increased. The pericardium was incised in the direction of the wound, allowing the escape of considerable blood, and the index finger was inserted into the pericardial sac. It failed to locate the wound in the heart, but palpation of the inner surface of the pericardium revealed an opening in it, corresponding in position to the original surface wound. The exposure of the heart was rapidly improved by making a "trap door." For this, the incision was carried upward along the sternum and outward along the lower margin of the third costal cartilage. The cartilages of the third and fourth ribs were divided close to the sternum, the third being readily exposed by retracting the soft parts upward. The 2 cartilages were then carefully lifted, separated from the pleura, and fractured at the costochondral junction, forming a flap with skin and muscles attached; resection of the fifth cartilage was contemplated but was delayed and did not prove necessary. The internal mammary was clamped and ligated above and below when exposed. The opening in the pericardium was enlarged by an incision upward near the sternum, making a triangular flap. Hemorrhage was very free; the operative field was a lake of blood in which were churned bubbles of air.

Palpation revealed the rent in the heart, which admitted the tip of the index finger. As the finger was withdrawn from the hole, a well-vaselined silk suture was passed from above downward on a fine curved intestinal needle; this was tied and left long. By gentle traction on this suture the heart was readily lifted and rotated, so that the wound was rendered visible and readily accessible. The wound involved the left margin of the heart somewhat posteriorly; it was about ½ in. in length, transverse on the long axis of the heart, and approximately 1½ in. above the apex. Though the wound was partially closed by the first suture, blood gushed out whenever the finger was momentarily lifted to pass a stitch. Five stitches were inserted and tied before the bleeding was completely controlled. All visible blood was then removed and the pericardium closed with interrupted catgut stitches. There was considerable tension between the edges of the pericardial wound, which caused some gaping between the stitches in the lower mesial part. The flap was replaced and chromic stitches used to repair muscles and fascia. The skin was closed with silk. In the outer angles of the wound, rubber tissue drains were inserted. At the lower mesial angle of the wound, a rubber tissue drain was inserted down to but not into the pericardium. After the wound in the heart had been closed, an infusion of 16 ounces of salt solution was given. The operation took about 30 minutes.

Postoperative Course.—For 24 hours after the operation the patient was restless, irritable, and thirsty. He was given morphin freely and saline continuously by rectum. During this time the highest pulse rate was 128; respirations were 24 to 28; temperature 102°. When the dressing was changed at the end of 16 hours and the drains were removed, a very large quantity of clear serum exuded from the drainage openings. A rubber tissue drain was therefore reinserted at the lower inner angle. A similar discharge occurred again at the next dressing, 30 hours after the operation. At that time the pulse had risen to 132; the temperature remained 102°. White blood cells were 19,000, polymorphonuclears 83 per cent. The serous discharge continued to be free until 48 hours after the operation, when the single remaining drain was removed from the lower and inner angle of the wound. At this time the pulse was 112, temperature 101°, respirations 24. The patient was refractory, refused to eat, and was very irritable and restless.

On the fourth day the condition was good, pulse 104 to 124, temperature 102°, wound dry and clean. On the sixth day a large amount of serum exuded from the wound, after which the pulse became very rapid. On the seventh day there was constant free discharge of clear serous fluid requiring frequent dressings. The patient still refused nourishment, was extremely weak, and appeared to be in serious condition. On the eighth day the patient was persuaded to eat. The wound was dry and clean, temperature normal, pulse 90. From this time the convalescence was uneventful. The patient was allowed up on the eighteenth day and discharged from the Hospital on the twenty-fifth day. He was seen 3 years after the operation. His condition was excellent.

FOREIGN BODIES IN THE HEART

Foreign bodies may reach the heart through the walls of the thorax, which is the most common route; occasionally through the blood-vessels; and rarely by ulceration through the wall of the esophagus. There are cases in which the site of entrance of the foreign body or the mechanism of its passage to the heart cannot be ascertained.

Besides the relatively common objects that have been reported, namely, bullets, buckshot, broken ends of weapons, needles and pins, the heart has been found to contain fish bones, slivers of wood or glass, tooth-picks, thorns, linen fibers, hair, paper wads, and arrow heads. Foreign bodies have been recorded in various parts of the heart muscle and within the chambers of the heart.

THE SURGICAL TREATMENT OF FOREIGN BODIES IN THE HEART

1. **Foreign Bodies Which Involve the Heart and Can Be Seen or Felt Externally.**—The involvement of the heart is suggested by movement of the foreign body synchronously with the heart. It must be understood that even cautious extraction, which is usually recommended, may be followed by serious hemorrhage. This has been illustrated by numerous observations. On the other hand, should extraction of the body be delayed, as is recommended by some, its prolonged presence favors infection. Neither of these courses can be recommended for routine use. The choice of procedure must depend upon the probability of penetration into the interior of the heart, the likelihood of infection, evidences of existing hemorrhage, size of the body causing the wound and the condition of the patient. Under some conditions, as in a wound produced by a needle or other small object, if there is no evidence of hemopericardium, the foreign body may be slowly withdrawn, preparations having been made for immediate operation if this should prove necessary. But in general, as has been emphasized under wounds of the heart, pericardiotomy should be performed. Thus, the lesion in the heart may be inspected, the wound repaired, the pericardium freed from blood, and provision made for drainage if this is indicated.

2. **Small Bodies Introduced Through Recent Wounds.**—The second class of foreign bodies in the heart includes small bodies such as bullets, wads and fragments of weapons which have been introduced through recent wounds. Under these conditions, the immediate treatment is that of a wound or a suspected wound of the heart. The recognition and removal of the foreign body is a coincidence and not the object of the operation.

3. **Foreign Bodies Which Have Become Permanently Lodged in the Heart.**—These demand operation only if they interfere with the cardiac function. That a foreign body may be present in the heart without noticeable effect has been demonstrated by numerous cases in which bodies, such as needles and bullets, have been discovered at autopsy, their presence having caused no disturbance during life. The effect of a foreign body upon the action of the heart is influenced more by its position than by its size. The physiological importance of certain cardiac areas is such that a local lesion or irritation is followed by profound disturbance of the heart action, even by arrest of the heart. Moreover, disturbance of the heart action is apparently apt to persist as long as a foreign body remains movable, but is likely to subside after it becomes fixed. The diagnosis of a foreign body in the heart and its accurate localization rest essentially upon the radiographic findings, as the clinical picture is in no way pathognomonic.

If the function of the heart is disturbed and X-ray examination reveals the presence of a foreign body, it is justifiable to expose the heart for the purpose of removing the body, provided the condition of the patient warrants the risk and there is a probability that the body lies in an accessible position.

CARDIAC MASSAGE

Rehn states that cardiac massage has been raised to the rank of an accredited procedure which is applicable in cases of imminent death as a result of arrest of the heart under general narcosis. Massage may be administered directly to the heart, or indirectly through the chest wall. Wiede states that the aim is, first, to stimulate the heart to renewed activity (it has been suggested that the expression of blood into the coronary vessels is important in this respect); and, second, to provide an exchange of the blood in the body during the suspension of the heart action. Schiff, the originator of the method, designated it as artificial circulation, but opinions differ as to the applicability of such a term.

Cardiac massage must be begun within a few minutes after arrest of the heart (5 minutes, Jurasz; 10 minutes, Wiede) because the cerebrum does not tolerate absence of blood supply for a long period, but it is uncertain how long after suspension of its activity the heart can be revived.

Direct massage has been recommended as a last resort in desperate cases of arrest of the heart. Injurious sequelæ have not been noted after recovery, but frequent failures have resulted.

METHODS OF APPROACH.—The methods of approaching the heart are as follows:

1. *Transthoracic Method.* Access to the heart is obtained by an osteoplastic flap containing the fourth and fifth, or the third, fourth and fifth cartilages.

2. *Transdiaphragmatic Method.* A vertical incision is made below the

ensiform cartilage opening the peritoneal cavity and a second incision is made through the diaphragm into the pericardium.

3. *Subdiaphragmatic Method.* This differs from the transdiaphragmatic in that only the abdominal incision is made; with the hand immediately beneath the flaccid diaphragm the heart is massaged.

In the *transthoracic method* the pleura is usually opened with resulting pneumothorax. The *transdiaphragmatic method* avoids pneumothorax but it does not appear to offer any advantages over the subdiaphragmatic method.

The *subdiaphragmatic method,* according to most authorities, is the simplest and quickest for rendering the heart accessible for massage and affords the best results. The abdominal incision is made and the right hand is inserted above the stomach and the left lobe of the liver, elevating the immobile diaphragm between the thumb and the next 2 fingers. The left hand is placed upon the precordial region for counter pressure. Applying the force steadily, the ventricle can be emptied. The heart dilates again and is again depleted, mainly by compression with the fingers of the right hand. The rate should be from 40 to 70 per minute. In successful cases, after a minute or less, a feeble thrill will be felt, a delicate contraction will follow, then a series of fluttering contractions, and, lastly, definite rhythmical but rapid contractions, with return of the pulse in the radials. The cardiac massage and artificial respiration should be continued for some time after the first spontaneous heart contractions and respiratory movements. (Description after White.)

Jurasz is in favor of employing subdiaphragmatic cardiac massage without delay in all cases in which the abdominal cavity is already open. In other cases it must be left to the judgment of the operator whether valuable time should be consumed in opening the abdomen to institute massage. In Jurasz's opinion the delay should never exceed 5 minutes.

TRENDELENBURG'S OPERATION FOR THE REMOVAL OF PULMONARY EMBOLI

An operation was devised by Trendelenburg for the rapid removal of emboli from the pulmonary artery. The operation was planned in the belief that there is a certain proportion of cases of emboli confined to one branch of the pulmonary artery in which death is delayed for a sufficient time to allow surgical intervention. The method has been employed in about 13 cases by Trendelenburg and his assistants and in a small number of cases in other clinics, but up to the present time no recoveries have been recorded.

In many cases of pulmonary emboli the patients die so quickly that operation is not possible; in another group the emboli are small and the patients recover without operation. According to Trendelenburg, there is a third and relatively large group in which an interval of 10 to 60 minutes occurs between the onset of the attack and death of the patient. It is for these cases that he advises operation; but it is obvious that immediate decision as to the need for and feasibility of operation in a given case must be a matter of considerable difficulty.

Willy Meyer has recently discussed the Trendelenburg operation in the *Annals of Surgery.* The article is well illustrated and contains the most important references. The following description of the technic is taken chiefly from Meyer's article.

An incision about 10 cm. in length is made along the second left rib from the border of the sternum. A second vertical incision is made from the sternoclavicular articulation downward to the third intercostal space. The soft parts are reflected as 2 triangular flaps, the exposed portion of the second rib and its cartilage are removed, and the third costal cartilage divided. The pleura is incised parallel to and 1 cm. from the left margin of the sternum, and a second pleural incision at right angles to the first is carried outward at the level of the second rib. The opening of the pleura with collapse of the lung renders the employment of differential pressure advantageous. The pericardium is next incised vertically at the level of the third rib. The opening in the pericardium is extended upward and backward, care being taken to avoid the phrenic nerve, which should lie external to the pericardial incision. Up to this point the operation should take about 5 minutes. By means of a Trendelenburg sound, a rubber tube is passed through the transverse pericardial sinus so as to surround the aorta and pulmonary artery. Traction is exerted upon the tube by an assistant, and an opening about 1 cm. in length is made in the wall of the pulmonary artery. A special forceps is passed into the opening and an attempt made to grasp and extract thrombi. Forty-five seconds should suffice for this step. The edges of the wound in the pulmonary artery are then lifted by special forceps and approximated by a special clamp. The tube which has controlled the circulation is then released, and the edges of the arterial wound are united by interrupted silk sutures. The wounds in the pericardium, pleura, and superficial parts are closed.

It has been suggested (Läwen, Sievers, Sauerbruch and Jeger) that compression of the 2 venæ cavæ, by which the circulation may be safely controlled for 6 to 8 minutes, may be substituted for compression of the aorta and pulmonary artery.

EXPERIMENTAL SURGERY OF THE HEART

The general principles of technic are here quoted from Carrel.

"The bad results following intrathoracic operations in experimental as well as clinical surgery are due to a lack of adaptation of the technique to the physiological conditions of the chest. The complications which often kill the animal or the patient are brought about directly or indirectly by the infection of the pleural or pericardiac cavities, or by the respiratory disorders caused by the penetration of the air into the thorax.

"The high death rate is due to the lack of understanding by many surgeons that the pleura and pericardium do not react against infection to the same degree as the peritoneum. The technique which permits a successful abdominal operation may be insufficient when used in thoracic surgery. It is, therefore, necessary to use in intrapleural operations better asepsis than exists in many hospitals and laboratories.

"The success of the more complex intrathoracic operations depends on the observance of a number of minute details of technique. It is necessary to remove some of the factors causing irritation of the pleura. Handling with forceps or contact with retractors, sponging, walling off with gauze, or the exposure of large surfaces to the air bring about irritation of the pleura and facilitate infection. As soon as the thoracic cavity is opened, the lungs should be covered with fine silk compresses impregnated with vaselin. The silk protects the pleura, without causing irritation, and prevents evaporation and desiccation of the tissues. In order to prevent cooling of the viscera, a piece of thick flannel is placed on the silk compresses; moreover, the temperature of the operating room is kept high. All traumatism to the unprotected pleura or pericardium is to be avoided.

"In the more extensive operations, when the chest is widely opened, the Meltzer and Auer method of intratracheal insufflation is used. This method has the very important advantage over all the others of permitting the respiratory exchanges to continue when respiratory movements have stopped or become insufficient."

Carrel attempted to discover "some method for the treatment of valvular diseases and localized sclerosis of the coronary arteries. Theoretically, many operations can be performed on the heart; incision and dilatation of stenosed valves, cuneiform resection and stenosis of the upper part of the ventricle in case of mitral insufficiency, curettage of endocardiac vegetations, grafting of new vessels on the auricle and ventricle, collateral circulation between two cavities of the heart, aorto-coronary anastomosis, etc." He states that "plastic operations on the heart are not very much more difficult than on any other part of the body. But to perform the operations without disturbing in an irreparable manner the functions of the nervous system and of the heart itself is a very complicated problem. The technique of these operations is far from being completely developed."

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CHAPTER XIII

THE BREAST

H. H. M. Lyle

ANATOMICAL CONSIDERATIONS

The breast consists of the parenchyma, the stroma or connective-tissue framework, and the fat.

The Parenchyma.—Stiles' admirable studies of the surgical anatomy of the breast have taught us that the gland tissue has a wider and more irregular distribution than was generally supposed. The main portion of the secreting substance is contained in the corpus mammæ. This has no distinct capsule but, radiating from the more compact central portion, are irregular processes of parenchyma. These peripheral processes extend into the paramammary fat and become more and more subdivided. Some of the cells pass forward along the suspensory ligaments of Cooper to the deep layers of the skin, others backward to the fascia, and still others pierce the pectoral fascia to enter the muscle

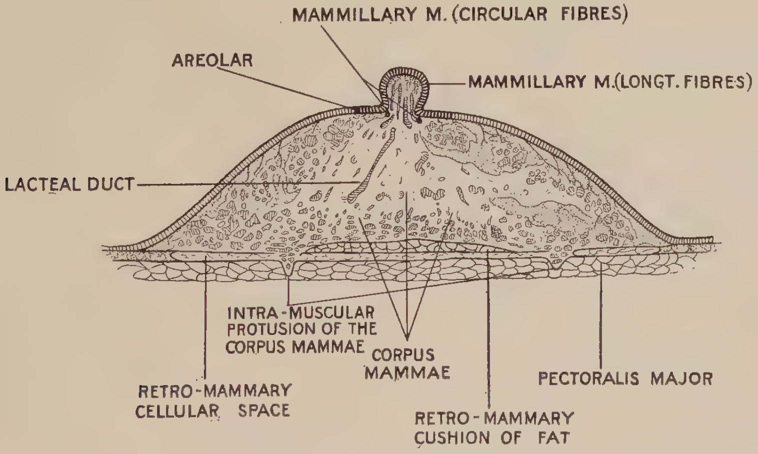

MAMMILLARY M. (CIRCULAR FIBRES)
AREOLAR
MAMMILLARY M.(LONGT. FIBRES)
LACTEAL DUCT
INTRA-MUSCULAR PROTUSION OF THE CORPUS MAMMAE
CORPUS MAMMAE
PECTORALIS MAJOR
RETRO-MAMMARY CELLULAR SPACE
RETRO-MAMMARY CUSHION OF FAT

Fig. 1.—The Mamma (Semi-diagrammatic) Showing Intramuscular Protrusion of Corpus Mammæ. (After Leaf.)

(Fig. 1). From the upper and outer quadrant a process of mammary tissue, known as the axillary tail, passes into the axilla. Shields has reported a case in which this tail crossed the axillary vessels. A process passes inward toward the sternum, another downward and inward toward the xiphoid, and still another passes downward and outward toward the external oblique. The parenchyma consists of 15 to 20 lobules, each lobe being a distinct compound racemose gland with its own excretory duct. The alveoli and the minute ducts leading from them are lined with cubical epithelium, the main excretory duct with columnar cells.

THE NIPPLE.—The nipple has the shape of a truncated cone, points forward and upward, and is situated a little below and internal to the center of the breast. In the summit of the nipple are numerous small pits into which the individual lactiferous ducts empty, and just below the nipple each duct dilates into a small sac. These sacs or lactiferous sinuses serve as temporary reservoirs for the milk. The nipple is surrounded by a dark ring, the areola, which contains from 12 to 20 modified sebaceous glands (tubercles of Montgomery). The mamillary muscle is found beneath the integument of the nipple and areola. The nipple has transverse circular and longitudinal fibers; the areola mainly circular, with a few fibers radiating from the base of the nipple. The circular fibers compress the milk ducts and aid the subareolar muscle in protruding the nipple; the longitudinal fibers retract the nipple. There is no fat in the nipple or immediately below the areola.

The Stroma or Connective-tissue Framework.—The stroma or connective-tissue framework, in which the blood vessels, lymphatics, and nerves ramify, forms a dense network of areolar and connective tissue. The relative proportion of parenchyma and stroma varies in different individuals and different portions of the same breast. The various septa, which split the breast into the different lobules, are branches from the superficial fascia. The close relation between the superficial fascia is of developmental origin, the breast being an appendage of the skin. The fibrous prolongations of the fascia, which pass from the skin to the anterior aspect of the corpus mammæ, are known as the suspensory ligaments of Cooper. Between the posterior surface of the breast and the fascia covering the pectoral muscles lies the retromammary space (submammary bursa of Velpeau). In this potential space retromammary abscesses develop and cancerous infiltration readily spreads.

The Fat.—Underneath the skin the fat exists in the form of lobules, separated by connective-tissue bands passing from the skin to the breast. In the corpus mammæ the fat is closely interwoven with the secreting tissues. On the posterior surface of the breast there is a well-developed pad of fat, the retromammary cushion.

The Blood Supply.—ARTERIES.—The arteries supplying the breast are: first, second, third, and fourth perforating branches of the internal mammary; the long thoracic, the pectoral branch of the acromiothoracic, and the superior branches of the axillary artery; second, third, and fourth perforating branches of the aortic intercostal arteries. According to Rodman, Piel has shown that the principal blood supply is superficial. The main arterial supply is derived from the perforating branches of the internal mammary. These pierce the pectoralis major, enter the superficial fascia, and are then distributed over the anterior surface of the gland.

THE VEINS.—The veins terminate in veins corresponding to the arteries, the principal vein being a branch of the internal mammary. The anastomosis of veins around the nipple is known as the circle of Haller. Like the arterial supply, the main venous trunks are superficial. **The superficial distribution of the blood supply is taken advantage of in the plastic resections for benign growths, the resections being made from the posterior surface of the dislocated gland.**

The Nerves.—The skin over the breast is supplied by the descending cutaneous branches of the cervical plexus and the lateral and anterior cutaneous branches of the second, third, fourth, fifth, and sixth intercostal nerves. The gland itself is supplied by perforating terminal branches of the fourth, fifth, and sixth intercostals.

The Position of the Breast.—According to Stiles:

> "Vertically the breast tissue extends from the second rib to the sixth costal cartilage at the angle, where it begins to sweep upward to the sternum; the horizontal diameter reaches from the edge of the sternum opposite the fourth costal cartilage to the fifth rib in the mid-axillary line. The inner hemisphere rests almost entirely on the pectoralis major; at its lowest part it overlies the upper part of the aponeurosis covering the rectus and external oblique muscles. The upper half of the outer hemisphere rests upon the greater pectoral, on the edge of the lesser pectoral, and to a slight extent on the serratus magnus, upon which it extends upward into the axilla as high as the third rib, where it comes into relation with the pectoral group of axillary lymphatic glands situated upon the inner wall of the axilla. The remainder of the outer hemisphere rests almost entirely upon the serratus, except the lowest part, which overlaps the fleshy digitations of the external oblique arising from the fifth and sixth ribs. It follows, therefore, that about one-third of the whole mamma lies inferior and external to the axillary border of the pectoralis major. These relations have been dwelt upon in detail because the surgeon must cut beyond the limits here mentioned if he wishes to remove the whole of the breast tissue."

Leaf, who in the main agrees with Stiles' localization, says that **when the arm is extended, ⅔ of the mammæ lie inferior and external to the axillary border of the pectoralis major.** We believe this to be the more accurate of the two.

The Lymphatics of the Breast, Axilla, Underlying Muscles, and Parietes.—A knowledge of the lymphatic system of the breast is essential to the proper understanding of the spread of cancer and for the scientific planning of the operative attack. **Clinical experience has taught us that if the normal lymph flow be blocked or retarded the cancer cells, instead of advancing along recognized lymph paths, will often take a direction quite the contrary.** In this way distant glands, seemingly without direct connection with the original focus, may become cancerous.

THE LYMPHATIC VESSELS OF THE BREAST.—The lymphatic vessels (Figs. 2, 20) are arranged in 2 groups: the cutaneous and the glandular or mammary. The *cutaneous group* is composed of central and peripheral vessels. The central vessels form an intricate network around the nipple and areola. From this meshwork trunklets pass into the subareolar plexus of Sappey, which plexus also receives the majority of the mammary lymphatics. Handley claims that they "drain chiefly into the deep fascial plexus and pass indirectly to the axillary vessel," a conclusion that accords with other known facts of dissemination, and especially with the work of Heidenhain. The peripheral set passes to the fascial plexus on the pectorals and ends in the central group of axillary glands. The cutaneous lymphatics may anastomose with the lymphatics of the other breast. Some of the lymphatics from the skin of the inner portion of the breast may drain into the lymphatics which run with the perforating branches of the internal mammary, while others may pass into the central group of glands of the opposite axilla. Poirier and Cuneo have described a set of vessels which drain the upper part of the breast and pass directly over the clavicle into the supraclavicular glands. Occasionally these same lymphatics empty directly into the infraclavicular glands.

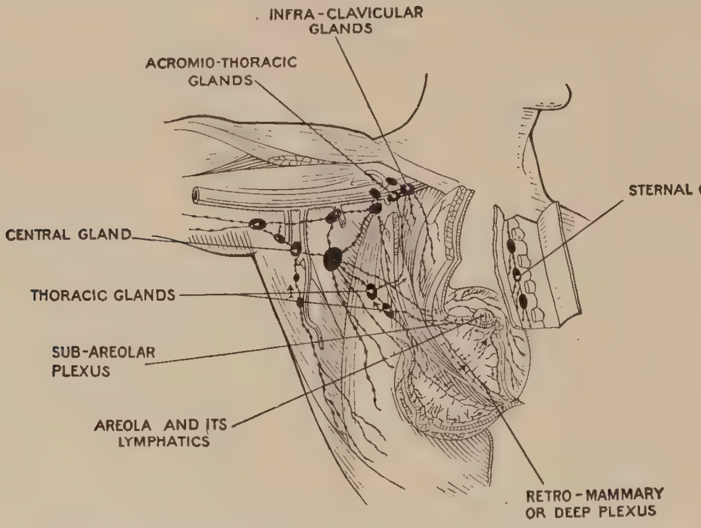


FIG. 2.—DIAGRAM SHOWING LYMPHATICS OF BREAST. (After Leaf.)

The *glandular lymphatics* commence in the perilobular connective tissue and follow the milk ducts, the majority emptying into the subareolar plexus, the remainder passing to the fascial lymphatic plexus. The subareolar plexus is "the chief collecting depot" of the intermammary plexus. It receives lymph from the areola, the nipple, and the major portion of the gland. From the plexus 2 and 3 trunks pass upward and outward to the central glands of the axilla, or before reaching the axillary glands they may enter the 2 glands lying on the third digitation of the serratus. This arrangement is considered by Leaf to be the most usual. **The surgical significance of this fact is that these glands may become involved before the axillary glands, and consequently should always be felt for.**

The following additional lymph channels are given by Leaf:

> "(a) One or more vessels either arise separately in the mamma or dissociate themselves from the principal lymphatic channel, then perforate the pectoralis major and run either into the acromiothoracic or infraclavicular group of glands (Fig. 2). Grossman has injected this trunk three times in thirty different subjects.
>
> "(b) One or the other of the two thoracic glands which lie on the serratus magnus may send an emissary (Fig. 2) in front of or behind the pectoralis minor or perhaps both, and thus discharge a portion of its lymph directly into the acromiothoracic group, while the rest, traveling along the principal lymphatic channel, empty themselves into the central group of glands.
>
> "(c) The lymphatics from the inner extremity of the breast follow the course of the perforating branches of the internal mammary artery; that is, they perforate the pectoralis major and internal intercostal muscles and join the internal mammary trunk which ends in the sternal glands. The latter are usually situated in the first, second and third intercostal spaces."

Oelsner found several channels at the internal border of the mammary gland which pierced the pectoralis major and entered the thorax through the fourth intercostal space. Some of the vessels followed the intercostal vessels to the spine. **It is through these latter channels that cancer may advance to the spine.**

THE LYMPHATIC ANATOMY OF THE PARIETES AND THE STRUCTURES OVER WHICH THE BREAST LIES.—This includes the lymphatic fascial plexus, the lymphatics of the pectorals, the serratus magnus, the intercostals, the external oblique, and the rectus.

The intimate relationship and the surgical importance of the breast and the fascial lymphatic plexus have been ably brought out by Handley. The following description is taken from his work (7):

> The Fascial Lymphatic Plexus (Fig. 20).—"The lymphatic plexus of the pectoral fascia is often spoken of as if it were an anatomical entity. It is in reality merely a conventional subdivision of the deep fascial lymphatic plexus, whose network of intercommunicating channels invests the entire body. This great plexus is divisible by the median plane of the body, and by two horizontal planes passing through the clavicles and through the umbilicus, respectively, into six catchment areas, three on either side, draining as the case may be into the cervical, the axillary, or the inguinal glands. Within each area a special set of trunk lymphatics arises from the plexus and converges on the corresponding set of glands. The line, or rather zone, separating any two adjacent areas, may be called the lymphatic water-parting, and is anatomically a zone of narrow, tortuous channels nowhere traversed by trunk lymphatics, a region consequently where the lymph stream is at its feeblest and where even very fine particles are liable to be arrested. The general idea, then, which we have obtained, of the parietal lymphatic system, is that of a vast horizontal network of fine channels, coextensive with the surface of the body and receiving above numberless fine vertical tributaries, which convey to it the lymph from the skin and its appendages. Among the latter we must include the breast. On its deep aspect the

plexus receives tributaries from the subjacent tissues. From this great plexus, which lies in the subcutaneous fat upon the deep fascia, the lymph is conveyed by six sets of lymphatic trunks, each draining a definite area, to the cervical, the axillary, or the inguinal glands."

THE LYMPHATICS OF THE SERRATUS MAGNUS.—There are 2 sets, the superficial and the deep. The lower portion of the superficial lymphatics follows the branches of the subscapular artery, entering the subscapular and the central axillary glands. The upper branches drain into the infraclavicular glands. The deep set communicates with the external intercostal glands.

LYMPHATICS OF THE EXTERNAL INTERCOSTAL MUSCLES.—The lymphatics of the external intercostal muscles pass into vessels which run posteriorly in each space and drain into the intercostal glands.

LYMPHATICS OF THE INTERNAL INTERCOSTAL MUSCLES.—These run from before backward and drain into the internal mammary chain.

THE LYMPHATICS OF THE PECTORAL MUSCLES.—The lymphatics arising from the septa which run over the muscle drain into the infraclavicular, the acromiothoracic, and the thoracic groups of the axillary glands. On the inner side of the muscle some of the lymphatics empty into the internal mammary glands. The lymphatics of the minor follow the same course.

THE LYMPHATICS OF THE EXTERNAL OBLIQUE AND RECTUS MUSCLES.—The lymphatics of the abdominal wall follow the arteries which supply it. The rectus is supplied above by the superior epigastric, below by the deep epigastric, laterally by the lumbar arteries. **In the region of the umbilicus, there is an intimate connection between the lymphatics of the rectus muscle and the lymphatics of the triangular ligament of the liver (Fig. 21). When cancer invades the lymphatics of the rectus and advances as far as the umbilicus, it may spread to the liver by the triangular ligament, downward in the direction of the deep epigastrics to the external iliac glands, or backward along the lumbar arteries to the aortic glands.**

The upper portion of the external oblique is supplied by branches of the musculophrenic, which perforates opposite the ninth rib. The lymphatics accompanying it enter the internal mammary group (sternal glands).

AXILLARY GLANDS.—Wide variations in number and position of the axillary glands (Figs. 2, 20, 34, 39) occur. The various groups have been classified by Leaf as follows:

"(a) Central: Two to five glands usually about the size of almonds, embedded in the axillary fascia.

"(b) Subcapsular: Three or more large glands lying over the dorsalis scapular artery and the termination of the subcapsular vein.

"(c) Pectoral: One or more small glands lying to the inner side of the axillary vein behind the pectoralis minor, some members of this group being often found just above the upper border of the pectoralis minor at the origin of the acromiothoracic vessels.

"(d) Infraclavicular: A few small glands lying on the serratus magnus above the pectoralis minor and to the inner side of the axillary vein immediately below the clavicle.

"The less constant groups consist of:

"(a) Two or more small glands situated at the commencement of the subcapsular vein, as it lies on the serratus magnus.

"(b) A few glands lying on, or immediately under the lower margin of the pectoralis major, in front of the second or third serration of the serratus magnus.

"(c) A few glands are occasionally seen between the pectoralis major and minor muscles over the course of the pectoralis branches of the acromiothoracic artery.

"(d) A cephalic gland is occasionally found in the groove between the pectoralis major and the deltoid. It may be immediately below the clavicle or one and a half inches lower down to the outer side of the axillary vein."

EXTRA-AXILLARY GLANDS.—Most of the glands are situated within the axilla. The following are found without: One of the subscapular group at times projects backward and lies between the teres minor and infraspinatus (this gland is liable to escape notice and a special search should always be made for it); some of the infraclavicular group may be to the outer side of the axillary vessels; the cephalic gland, when present, lies over the cephalic vein external to the axillary vein. These glands have to be removed separately. Beside the larger lymphatic gland visible to the naked eye, there are innumerable tiny nodules of lymphoid tissue, each of which is a miniature lymphatic gland. Stiles states that fat lobules may, if the need arise, develop into lymphoid tissue.

The Axillary Fascia.—It will be readily seen that an operation which does not remove the axillary fascia in toto (Figs. 29, 32, 33) fails to remove all the lymphatic tissue from this region; hence, the importance of a knowledge of the fascia. There are 3 distinct fasciæ lining the axilla:

(1) The costocoracoid or suspensory ligament is attached to the clavicle by a double root, which incloses the subclavius muscle. Lower down it again splits in two, to surround the pectoralis minor, reunites, and blends with the subcutaneous tissue of the skin. From its under surface it gives off the ligament of Gerdy, which passes to the sheath of the axillary vessels.

(2) The deep axillary fasciæ covering the muscles form the posterior and external walls of the axilla; a deep internal fascia covers the serratus magnus; and a deep anterior fascia attached above to the clavicle, and covering the posterior surface of the pectoralis major, forms the greater portion of the anterior wall of the axilla.

(3) The fascia covering the lower portion of the axilla extends from the fascia over the serratus magnus to the fascia of the arm. It presents an oval opening, the outer edge of which is known as the arm arch (Armbogen), the inner edge as the axillary arch (Achselbogen).

THE SURGICAL TREATMENT OF THE ANOMALIES AND DISEASES OF THE BREAST

DEVELOPMENT ANOMALIES

Micromazia.—Micromazia is the condition in which the infantile type of mamma persists after puberty. It is often an expression of defective genital development, and at times is associated with malformations of the pectoral muscles and chest wall. The condition can be somewhat improved by systematic exercises and massage. If, for esthetic reasons, it is desirable to increase the fullness of the breast, a portion of fat can be taken from abdomen or buttock and transplanted into the retromammary space. Gaillard Thomas' crescentic incision (see page 642) is used. A graft of suitable dimension is inserted between the posterior surface of the breast and the anterior surface of the pectoralis major, and is fixed in place by catgut sutures. The wound is closed without drainage and a supporting bandage applied.

Polymazia (Supernumerary Breast) and Polythelia (Supernumerary Nipples).—These conditions are not uncommon, but removal is only indicated for esthetic reasons or where the supernumerary organ is giving rise to pain or discomfort. These conditions arise during lactation and are encountered most frequently in the axillary mamma, rarely in the inguinal mamma. If mastitis and abscess occur, they should be treated according to general surgical principles.

ANOMALIES OF SECRETION

Agalactia.—The complete absence of secretion is, as a rule, bilateral. The treatment consists in endeavoring to induce lacteal secretion by cupping the nipple and by applying a vigorous suckling infant. Williams has proposed the application of electricity and massage to the breast and ovary. Tonics, galactagogues, etc., are indicated. The therapeutic value of specific organotherapy for this anomaly has not yet been determined.

Galactorrhea.—The flow of milk may be excessive during lactation, or may be unduly prolonged (galactorrhea). As a rule, the condition is bilateral.

If the secretion persists after weaning and is undermining the patient's health, every means should be taken to check it. The breast is treated locally with a compression bandage, belladonna plasters, compound iodin ointment; and internally by belladonna, bromids, KI, extract of corpus luteum, and saline purgatives. If palliative means fail and the drain on the system becomes too great, resort may be had to amputation. As an alternative Baumgartner has suggested resection with ligature of the principal arteries and lactiferous ducts.

Heterochronic Lactation.—This comprises all lactation occurring outside the normal nursing period. For the consideration of that occurring in the newborn and at puberty, see Engorgement (page 623). In the male it may accompany gynecomastia; in the female it is not uncommon, and is often the result of a mechanical irritation of the nipple. Vogt reported a case of lactation occurring after a severe burn of the chest, the secretion having evidently been started up by the intense local congestion caused by the burn. The question of the relationship between lactation and the function of the ovary is not definitely settled, but it appears that the corpus luteum of the ovary secretes a substance which, entering the general circulation, affects the function of the mammary gland. Baumgartner, on account of the antagonism between the genital function and lactation, suggests the use of the extract of corpus luteum for the treatment of a galactorrhea and heterochronic lactation, and the employment of the ovarian extract in the cases where the milk secretion is impaired by a diminution of the menses. The ovarian extract increases the ovarian congestion and thus relieves the breast.

THE TRAUMATIC AFFECTIONS OF THE BREAST

The following conditions will be considered under this head: wounds, contusions, and burns.

Wounds.—The treatment of wounds of the non-lactating breast presents no special difficulties. When the breast is wounded during the period of lactation and the lactiferous ducts are involved, a milk fistula may develop, which will spontaneously disappear, however, if lactation be stopped.

Contusions.—These lesions are frequent and often accompanied by severe pain. They vary from a simple ecchymosis to the formation of a large hematoma. Examples of mammary abscess following traumatism are not uncommon; on opening such an abscess, pus mixed with broken-down blood-clots will be found. A certain number of cases of chronic mastitis give definite histories of repeated trauma. The relationship between tumor formation and traumatism is still problematic. The treatment consists in the application of weak refrigerant lotions and a compression bandage, and in the removal of all sources of chronic irritation.

Burns.—Burns of the breast often accompany burns of the neck and thorax. Even if the nipple and lactiferous ducts are destroyed by cicatricial contraction, the breast may not atrophy; and if pregnancy ensues, the possibility of inflammation, abscess formation, and gangrene is to be considered.

The superficial burns in this region are best treated by the dry hot-air method; the deeper burns by the usual surgical methods.

CONGESTIONS AND ENGORGEMENTS OF THE BREAST

Under this heading will be considered: mastitis of the new-born (*mastitis neonatorum*), mastitis of adolescence (*mastitis adolescentium*), and milk engorgement (lactation mastitis).

Mastitis Neonatorum.—The breasts of the new-born of both sexes are subject to hypertrophy. The epithelium of the ducts undergoing an active proliferation, the gland becomes swollen and tender, and a few drops of milk fluid can be expressed. The condition is of little importance, and, as a rule, subsides in a few days unless the breast is irritated or infected. The treatment consists in the application of soothing lotions. If an abscess develops, it should be opened and drained.

Mastitis Adolescentium.—This condition is observed both in boys and girls, and is an expression of physiological development. The treatment consists in the application of support, moderate compression, and soothing lotions.

Lactation Mastitis.—An extreme degree of physiological engorgement may take place during early lactation due to the blocking or the retention of milk in the gland. This retention may be caused by the imperfect formation of the nipples, the blocking of the lactiferous ducts, or the failure of the child to suck. If possible, remedy the causative factor and relieve the milk engorgement by massage, the breast pump, and extra nursing. If these means fail, lactation should be terminated and the further secretion of milk arrested by the application of a firm compression bandage, and the administration of saline purgatives, belladonna, potassium iodid, etc. **The milk engorgements derive their surgical importance from the fact that they are one of the chief predisposing causes of pyogenic mastitis.**

ACQUIRED DEFORMITIES OF THE BREAST

Pendulous Breast.—Flaccid and pendulous breast may give rise to neuralgia, dragging pains, chronic congestion (Velpeau's hyperstatic engorgement), chronic inflammatory changes, and submammary eczema. A pendulous hypertrophied breast is, for cosmetic and functional reasons, a drawback in the theatrical and operatic professions. Küttner quotes a case of an opera singer who, on account of the hypertrophy, had to bandage her breasts to the abdomen. This limited her breath so that her voice lost in tone and volume. Palliative means of compression bandages, massage, and support failing, some form of mastopexy, resection, or excision with a plastic reformation of the gland, must be performed.

MASTOPEXY (GIRARD).—Gaillard Thomas' crescentic skin incision is made under the breast, the breast loosened from the pectoral fascia and turned upward and backward so that the under surface of the breast is anterior. A blunt separation of the pectoral muscles is made, and the cartilage of the second rib laid bare. A strong, slightly curved needle is threaded with heavy chromic catgut and passed from above downward in the form of a mattress suture, through the cartilage of the rib and the upper pole of the gland sheath. The suture is tightened and the breast raised to the desired level. Four loop sutures of different lengths are placed in the posterior surface of the gland extending through its entire breadth and taking a point of support from the first suture. The sutures, when drawn tight, act as puckering strings, gathering the spread-out gland into a hemispherical shape. The posterior surface of the gland is then sutured to the pectoral fascia by numerous interrupted sutures and the wound closed. Strips of fascia lata passed around the second rib and used as slings to support the breast, may be found of value.

LATERAL MASTOPEXY.—Verchère (1898) devised an operation called lateral mastopexy. He removed a triangular-shaped portion of skin and subcutaneous tissue from the region between the axilla and the outer border of the pectoralis major and the breast, the base of the triangle being vertical and the apex toward the breast. He sutured the wound in a Y-shaped manner, forcing the breast upward and outward. This method does not restore the breast to its normal position, and is, therefore, inferior to Girard's operation.

EXCISION OF THE MAMMARY TISSUE WITH THE REFORMATION OF A MAMMA BY SKIN AND FAT.—This operation was performed by Küttner on a young opera singer before mentioned. It was important, on account of the interference with her voice, to remove the hypertrophied breasts. From a cosmetic standpoint it was almost as important that no scar be seen and that the substitute breasts be so constructed as to allow the wearing of a low-neck dress. In performing this operation, Thomas' crescentic incision was made, the mammary gland removed, and the defect filled with fat. If a sufficient fat tissue cannot be secured in the mammary region, a transplant is taken from the abdomen or buttock. The shape, tone, and fullness of the newly constructed mamma can be greatly improved by systematic massage, and within 3 to 6 months surprisingly natural-looking breasts can be obtained.

RESECTION.—Pousson and Michel excised a large portion of the skin and glandular tissue from the upper circumference of the breast and fixed the remaining portion to the pectoral fascia. Dehner fixed the breast to the periosteum of the third rib. The disadvantage of this operation lies in the prominence of the scar, which sometimes takes on a keloid character.

Atrophy of the Breast.—The volume of the breast is not an indication of the development of the gland, certain women with large breasts being unable to nurse, while of others with small breasts the reverse is true. Atrophy is normal after the menopause, and abnormal when it appears after the first child. It may be due to local causes, such as mastitis or the compression of a corset. Atrophy has been encountered after mumps, with chlorosis, syphilis, and tuberculosis, and is present in cretins, degenerates, and in infantilism.

Treatment consists in remedying the constitutional fault, if possible, and employing means to excite lactation (see Anomalies of Secretion).

Diffuse Hypertrophy of the Breast.—The treatment varies with the type: (1) diffuse hypertrophy not associated with pregnancy; (2) diffuse hypertrophy associated with pregnancy.

(1) DIFFUSE HYPERTROPHY NOT ASSOCIATED WITH PREGNANCY.—The following conditions are considered under this heading: the so-called hypertrophy of puberty or virginal hypertrophy; hypertrophy occurring in intermittent fever; hypertrophy of the breast in elephantiasis.

Hypertrophy of the breast associated with intermittent fever yields to appropriate quinin therapy. Enlargement of breasts in elephantiasis may call for amputation.

DIFFUSE VIRGINAL HYPERTROPHY.—Diffuse virginal hypertrophy is of a progressive nature, the growth being either rapid or slow, and with little or no tendency to spontaneous cure. In the 27 cases reported by Delbet, only one returned to the normal.

Palliative Treatment.—The palliative treatment is employed in the milder and earlier cases. It consists in the application of compound iodin ointment, compression bandages, the recumbent position, a dry, spare diet, and the internal administration of KI. If acute and associated with the suppression of the menses, this condition is to be actively treated. The failure of palliative means is not surprising when we consider the progressive nature of the disease and the close relationship it bears to a diffuse fibroma.

The *operative measures* consist of (1) resection, with or without mastopexy; (2) amputation.

Resection.—Successful resections have been performed by Morestin, Verchère, Pousson, and Dehner. Morestin exposed the posterior surface of the breast by means of Thomas' semicircular incision and resected a disk-shaped segment from the under surface of the breast. The hemorrhage was controlled by compression and the wound closed with fine sutures. A cure was obtained in the left breast, but the condition continued in the right. The operation was repeated, and the second time resulted in a cure. In a subsequent case, Morestin, after the resection, fixed the cut surface of the breast to the aponeurosis of the pectoralis major. Dehner removed from the upper segment of the breast a large elliptical portion of skin, subcutaneous and hypertrophied mammary tissue. The fibers of the pectoralis major were separated by blunt dissection; the periosteum of the third rib exposed, and the breast sutured to it. The inflamed condition of the skin beneath the breast prevented the use of a submammary incision.

Amputation.—Amputation is indicated if all palliative means have failed; if the progressive growth is causing distressing symptoms; or if the breast is edematous and engorged with blood. As a preliminary precautionary measure, to minimize the loss of blood, the patient is put to bed, the parts supported, and a compression bandage applied. One breast is removed at a time, thus diminishing the shock and lessening the hemorrhage. A moderate interval of time is allowed to intervene before the second breast is removed, as a spontaneous diminution of the second breast, after the removal of the first, has been reported. The larger breast is removed first. Ample skin flaps are turned down, and if the tumor is very vascular, the hemorrhage is controlled by passing 2 strong pins through the growth (Porter) and winding rubber tubing beneath them. The growth is then cut away, the constrictor loosened, and the bleeding points are secured. If advantage is taken of the anatomical fact that the principal blood supply of the breast, both arterial and venous, is superficial, and the dissection is carried out between the posterior surface of the gland and the pectoral fascia, the loss of blood will be greatly diminished and the use of pins and constrictors will be unnecessary.

(2) Diffuse Hypertrophy Associated with Pregnancy.—Here the expectant plan of treatment should be employed, as the completion of pregnancy produces an amelioration of the condition. In the acute cases means to induce lacteal secretion, as cupping of the breasts or daily application of a suckling child, should be employed. Urgent symptoms call for the termination of the pregnancy or the amputation of the breasts.

Prognosis.—The virginal hypertrophy has less tendency to spontaneous arrest. In hypertrophy of pregnancy 50 per cent. of the cases regress after delivery, and of the remaining 50 per cent. only 20 per cent. require amputation. According to Porter, in untreated cases, 1 in 16 dies. Certain complications may arise which make the prognosis much more grave. These breasts are more liable to infections, abscess formation, and gangrene, and abortions are common. Cachexia has occurred from the enormous size of the tumor. Curvature of the spine and chest deformities have been reported. If the operation is carefully carried out, the mortality is negligible and the cure certain.

Gynecomazia or Gynecomastia.—The term gynecomazia or gynecomastia is applied to hypertrophy of the breast occurring in the male. Cases of a real glandular hypertrophy in contradistinction to a heaping up of fat and fibrous tissue are rare. The condition may be unilateral or bilateral. The gynecomastia may be essential, as observed in patients otherwise normal; or it may be associated with a congenital or acquired testicular atrophy. The latter condition may be the sequel of an orchitis due to trauma, mumps, syphilis, or tuberculosis. No treatment is necessary, unless it gives rise to deformity or becomes troublesome. In the mild case a compression bandage with the internal administration of KI is indicated; in the acquired forms organotherapy has been suggested; in the syphilitic the treatment is that of syphilis.

VASCULAR AND NERVOUS AFFECTIONS OF THE BREAST

Under this heading the following will be considered: spontaneous ecchymosis, bloody discharges from the nipple, and mastodynia.

Spontaneous Ecchymosis.—Spontaneous ecchymosis is found in hysterical women, in hemophiliacs, and accompanying certain disorders of menstruation. The treatment of the so-called spontaneous ecchymosis consists in the removal of the causative factor and in the application of light compression and soothing lotions to the breast in the acute stage, and later of gentle massage, heat, etc., to promote absorption.

Bloody Discharge from the Nipples.—As a bloody discharge from the nipple is the classical sign of papillary cystadenoma, it is incumbent on the surgeon to prove that the so-called spontaneous bleedings attributed to vicarious menstruation, etc., are not manifestations of a new growth. The proof will require an exploratory operation.

Mastodynia (Neuralgia of the Breast).—Irritable breast is most common in neurotic young women who have, associated with it, disturbances of the reproductive system. This requires treatment of the neurasthenia and of the genital conditions. A bandage is applied with the object of supporting the breast and keeping the patient from handling it. Local analgesics, belladonna plasters, hot-air douches, galvanism, and the application of the tincture of iodin are used. In the severe, persistent cases alcohol injections of the nerves have been suggested. Baumgarten suggests the evulsion of the involved intracostal nerves, as they escape from their canals. Finney reports a case in which it was necessary to amputate the breast in order to relieve the intense pain.

AFFECTIONS OF THE NIPPLE

Affections of the nipple are a fertile source of much misery in suckling and the cause of most mammary infections. The treatment of the following conditions will be considered: (1) deformities, (2) inflammations, and (3) tumors.

1. Deformities.—One or both nipples may be small, umbilicated, or invaginated. The condition is congenital or the result of a cicatricial contraction following a previous inflammation. Under these conditions suckling becomes impossible or is difficult and unsatisfying. The redoubled efforts of the child may produce an irritation rendering the formation of cracks and fissures possible, and thus predisposing the breast to infection.

SMALL OR ATROPHIC NIPPLES.—A preparatory course of treatment, with the object of developing the nipple, should be begun as soon as the condition is recognized. Gentle traction, systematic massage, and cold applications to stimulate the contraction of the areolar muscular fibers are employed. Between the treatments the nipple is surrounded with a thick ring of plaster, and a firm compression bandage applied. This gradually renders the nipple more and more prominent. In certain villages in France it is the custom to prepare the breasts by offering the nipples to the suckling of a vigorous infant.

UMBILICATION.—In this condition the nipple is well formed, but imprisoned in a depression produced by an overhanging ridge of skin. Nursing is impossible without surgical intervention. Kehrer has devised an operation called mammilliplasty, to remedy this deformity. Good results have been reported by Herman, Rapin, and others.

MAMMILLIPLASTY (Fig. 3).—Two crescentic-shaped portions of skin are removed from the overhanging skin edges, the deep adherences of the lactiferous ducts are carefully freed, and the edges of the wound sutured. Where the deformity is marked, a complete ring of skin is removed from the overhanging edge, and the inner circular edge of skin is united to the outer edge by interrupted silk sutures. The resulting traction levels the projection edge and forces the nipple to rise. The after-treatment consists in measures to develop the restored nipple (see Treatment of the Small Nipple).

INVAGINATION.—This is the most advanced and the rarest of the deformities of the nipple. Congenital or acquired invagination is not to be confounded with the retraction caused by malignancy. The treatment is aimed at keeping the depression dry and clean, and avoiding eczema, ulceration, and mastitis.

2. **Inflammations of the Nipples.**—Excoriations, cracks, and fissures are the commonest lesions of the nipple. They occur during lactation, and, as a rule, are the result of a lack of cleanliness. They derive their importance from the fact that they are often the starting point of an acute mastitis. The soft and delicate nature of the areolar skin, the constant moisture, and the repeated irritation keep the fissures from healing. The pain may be so severe that the patient cannot nurse, with the result that the breast becomes engorged, which still further favors the spread of the infection. Prophylactic measures should be instituted during the latter months of pregnancy. Pressure or friction of the nipple must be avoided, and, if retracted, it should be gradually withdrawn. During lactation the nipple should be washed with warm boracic solution, dried, and dusted with boracic powder or anointed with liquid albolin. Strict surgical cleanliness should be observed by the nurse and her hands sterilized before touching the nipples. The infant's mouth should be kept in good condition. If the fissures are painful, a shield should be worn. This failing, nursing should be discontinued. Deep fissures and cracks should be touched with a silver nitrate stick. In very sensitive cases it will be found necessary to precede the application of silver nitrate with cocain. If there is a tendency to form crusts, these are to be gently removed after softening them in a solution of equal parts of 90 per cent. alcohol and glycerin.

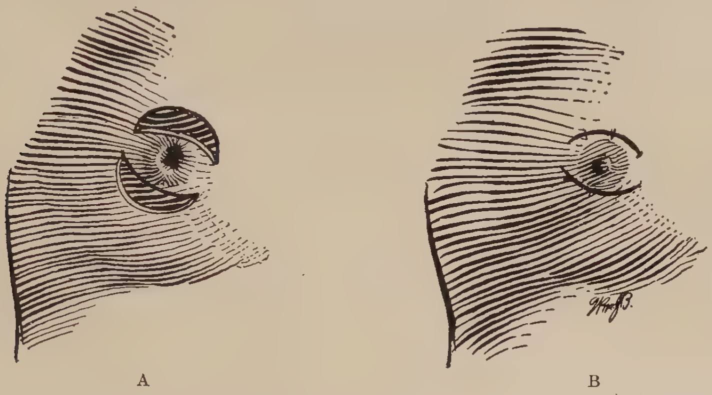


FIG. 3.—PLASTIC OPERATION FOR UMBILICATED NIPPLE. A—The crescentic shaded area represents the portions of skin removed. B shows the inner and outer edges of the crescents sutured.

ECZEMA OF THE NIPPLE.—Eczema may occur independently of pregnancy and lactation. The treatment does not differ from that of eczema anywhere else in the body. The chronic form may simulate Paget's disease.

SYPHILIS OF THE NIPPLE.—Chancre in this region is apt to be atypical, and may vary from a shallow fissure to a large indurated ulcer. The treatment is that of syphilis.

3. **Tumors of the Nipple and Areola.**—Sebaceous cysts, arising in the glands of Montgomery, are the most frequent tumors. Others are papillomata, angiomata, etc. The treatment is excision.

PAGET'S DISEASE OF THE NIPPLE AND AREOLA.—Treatment is carried out along the lines of carcinoma of the breast.

INFLAMMATION OF THE BREAST

The inflammatory diseases of the breast are divided into 2 classes, the acute and chronic. The cause of both is infection, but the differences in symptoms, prognosis, and treatment required necessitate a detailed study.

Acute Inflammation

In the treatment of acute mastitis the following conditions will be considered: (1) mastitis of general infection, (2) mastitis of local infection, (3) lymphangitis, (4) galactophoritis, (5) abscess, (6) gangrenous cellulitis (diffuse phlegmon), and (7) ligneous phlegmon.

1. **Mastitis of General Infection.**—Acute and subacute inflammations of the breast may take place during mumps. The condition usually resolves without suppuration. Occasionally atrophy ensues. The treatment is that of mumps plus the application of support and soothing lotions to the breast. Mastitis has occurred after typhoid, and as a metastatic condition it sometimes complicates septic abortions, puerperal infections, and other pyemic conditions. The treatment is that of any pyemic abscess.

2. **Mastitis of Local Infection.**—Mastitis occurring during nursing is by far the commonest form. **Attention cannot be too forcibly focused on the almost constant predisposing cause—cracks and fissures of the nipple.** The appreciation of this fact is the foundation upon which the prophylactic and abortive treatments are based.

PROPHYLACTIC TREATMENT.—Imperfectly formed or unhealthy nipples are the most fertile source of cracks and fissures. The prophylactic treatment must begin with young girls. It is the duty of the family physician to see that the mothers instruct their daughters in the care, development, and protection of the nipples. For the prophylactic care of the nipples during pregnancy and lactation, see Diseases of the Nipple (page 629). Another safeguard of scarcely less prophylactic value is the prevention of milk engorgements (see page 623).

ABORTIVE TREATMENT.—The close relationship of the inflammatory lesions of the breasts to the lymphatics is readily understood when we consider that the sore nipples and cracks of lactation occur at the very moment when the lymphatic circulation of the gland is at its height. Pyogenic organisms, gaining an entrance through a crack or advancing down a duct, reach a succulent soil. The abortive plan consists in the active treatment of all cracks and fissures of the nipple, engorgements of the breast, lymphangitis, and galactophoritis. For the treatment of the cracks and fissures, see page 629; for engorgements, see Lactation Mastitis (page 624).

3. **Lymphangitis.**—Lymphangitis is treated by the application of wet dressings of liquor alumini acetatis, Thiersch's solution, etc., and by the employment of a supporting bandage. Cold, in the form of ice, is employed by many surgeons, while others have seen benefit result from the use of unguentum Credé.

4. **Galactophoritis.**—Galactophoritis is a purulent inflammation of the ducts and is charaterized by the escape of pus into the milk when pressure is applied to the breast. This insidious affection is the cause of many fatalities among infants. Atrophy, marasmus, purpura hemorrhagica, or signs of intestinal infection in the child should demand an immediate microscopical examination of the milk. If pus is found, the child should be instantly withdrawn from the breast and active means taken to provide duct drainage. Gentle massage with expression of the milk, the use of the breast pump, and Bier's suction cups are indicated. Between treatments the breast should be supported, and wet dressings of aluminum acetate applied. In addition to the local means, general treatment is instituted with the object of drying up the breasts and combating the infection.

5. **Abscess of the Breast.**—The care of any variety of acute mammary abscess in a nursing woman calls for both local and general treatment. The child should be taken from the affected breast and precautions instituted to prevent engorgements in the opposite one. If the child is to be weaned, and this is usually desirable, treatment aimed at the drying up of the milk is begun. The large absorbent surface presented by the breast and the anemic state of the patient make it imperative that the elimination of the toxins be secured by a free catharsis and diuresis; that the strength of the patient be supported by a wholesome diet; and that her resistance be increased by fresh air, sunlight, and the exhibition of iron.

The treatment of the following types of abscess is considered: (a) supramammary, (b) inframammary, and (c) retromammary.

(A) SUPRAMAMMARY ABSCESS.—Supramammary abscess (Fig. 4) develops in the cellulofatty subcutaneous tissue between the breast and the skin. The termination is by sloughing and ulceration of the integument. Although the breast tissue is involved but little, the skin destruction may be extensive. Supramammary abscesses are generally of lymphatic origin, as is evidenced by the early and constant existence of an axillary adenitis. This latter point is an aid in the differential diagnosis between the supra- and the inframammary abscess. Superficial suppurations in the form of common boils take place in the skin. These boils are commonly the direct result of an infection of the small sebaceous glands of the areola. The treatment consists of incision, evacuation of the contents, drainage, and the application of wet antiseptic dressings. The surgeon must assure himself at the time of operation that he is dealing with a superficial abscess and not with a superficial pocket of an inframammary hour-glass abscess.

(B) INFRAMAMMARY ABSCESS.—Inframammary abscess (Fig. 4) is the common form of abscess. The pus forms in the substance of the gland and, burrowing in various directions, soon forms a multilocular cavity. The multilocular character of these abscesses is accentuated by the fact that they are prone to be restricted where the pus has burrowed through the fascia or intramammary septa. Abscesses can thus assume a shape which can be compared to an hour-glass (Fig. 4). The communication between the deep and the superficial parts is represented by a narrow channel. The term collar-button abscess has also been applied (Velpeau's "abscès en bouton de chemise"). **The surgical significance of the collar-button type lies in the fact that a superficial anterior incision may be entirely inadequate to cure the condition.**

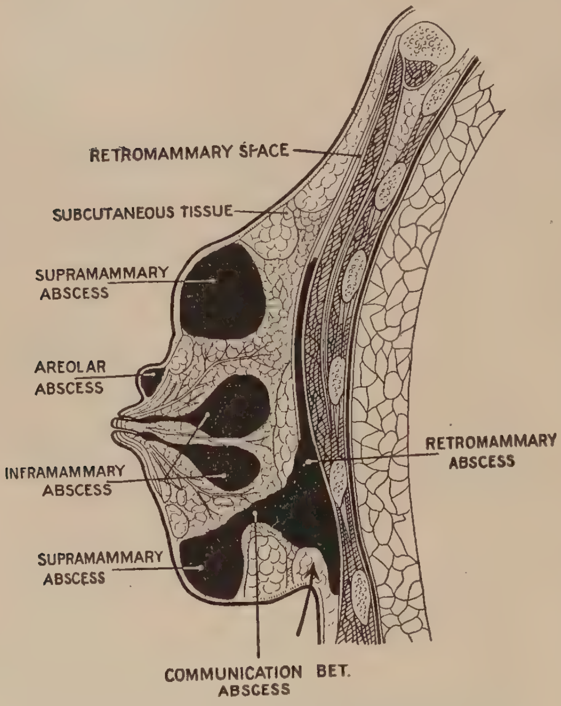


Fig. 4.—Types of Mammary Abscess Formation.

(C) RETROMAMMARY ABSCESS.—The 2 most common causes of acute primary retromammary abscess (Fig. 4) are the extension of an inframammary infection into the retromammary space and the breaking down of hematomas following contusions of the breast. Secondary retromammary abscesses arise as extensions from neighboring structures, necrosis of the ribs, perforating empyema, perforating abscesses of the lung, intestinal fistulæ, etc. They may also occur as a local manifestation in the course of a pyemia. These secondary abscesses are liable to become chronic. Clinically the retromammary abscess pushes the whole breast bodily forward. The base of the breast shows an area of edema; fluctuation can be detected at the periphery; and the pus, if left to itself, points at the lower and outer part of the breast or burrows into the axilla. Untreated, the prognosis is grave, owing to the possibility of a rapid extension in cellular tissue. If the natural drainage is insufficient, the abscess is liable to become chronic and leave numerous tortuous fistulæ; while an early, free incision in the thoracomammary fold offers a speedy prospect of cure. The prognosis and treatment in the secondary variety vary with the causative factor.

Operative Treatment.—When incising the breast the following points are to be kept in mind: The milk ducts must not be cut across; and, conditions admitting, the incision should be as far from the front of the gland as can be managed, if possible, in the thoracomammary furrow.

The following types of operation are employed in the treatment of acute abscess:

1. Small anterior radiating incision with drainage, in the thoracomammary furrow.
2. Multiple small radiating incisions and the application of Bier's hyperemic treatment.
3. Large anterior radiating incisions.
4. Areolar skin incision (Morestin).

(1) *A Small Anterior Radiating Incision with Drainage in the Thoracomammary Furrow (Shield's Operation)* (Fig. 5).—I prefer this method for the ordinary inframammary abscess. The following is a description of the operation as practiced by Shields:

> "So soon as elasticity and deep fluctuation are evident, an incision is made radiating from the nipple just large enough to admit the index finger of the operator, and this is deepened until pus flows. The finger is now passed into the cavity and in the vast majority of cases it will be found that the end of the digit may be brought fairly near the surface in a dependent position, and this is generally at the thoracomammary junction. In this situation it may especially be noted that scars are afterward hidden from view. Sometimes the finger passes toward the axillary margin, and occasionally the cavity is so large that a stout bent probe must be used to indicate the most dependent part of the abscess. In this situation the gland being well raised by an assistant, a free opening is to be made large enough to well evacuate the pus, and the finger being now introduced through this, the inferior opening, the operator will be surprised to find that the pus has burrowed about and is contained in loculi bounded by fibrous septa. All such septa and loculi must be broken by the finger and the numerous irregular spaces thus converted into one cavity. It is especially noteworthy that in many instances quite a narrow channel toward the nipple connects the main cavity of the deep abscess with the more superficial collection of pus opened anteriorly ('shirt-stud' abscess), and it will then be clearly understood how inefficient is drainage in the practice of those who are content with a small superficial incision in these cases. The remainder of the treatment is obvious: The cavity is well flushed out with whatever antiseptic agent the operator fancies, and a full-sized tube is introduced from below. The opening made near the nipple is closed with fine horsehair and painted with collodion. It readily unites with only a faint scar, and the

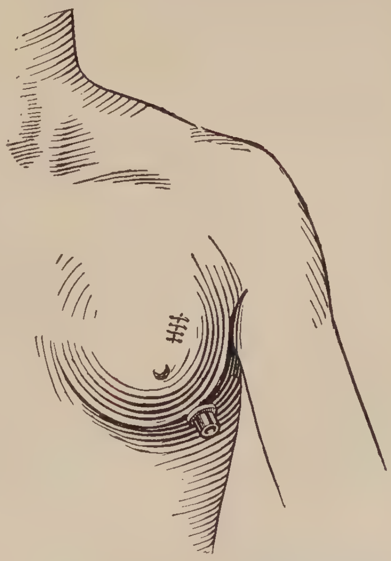


Fig. 5.—A Small Anterior Radiating Incision with Drainage in Thoracomammary Fold. (Shield's Operation.)

free drainage prevents the possibility of the re-collection of pus and a necessity for further operation. The tube, a very large one, can be left in the cavity as long as needful, and is slowly shortened and withdrawn."

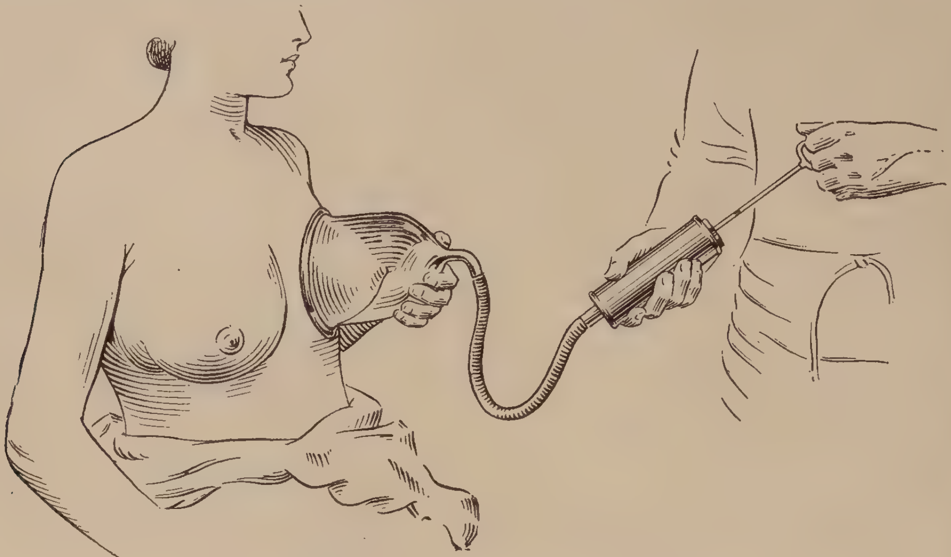


FIG. 6.—BIER'S SUCTION CUP APPLIED TO THE BREAST.

(2) *Multiple Small Radiating Incisions plus Bier's Hyperemic Treatment* (Figs. 6, 7).—Small punctures are made over the infiltrated area; a large suction cup slightly smaller than the breast is applied. Suction is maintained for 5 minutes, followed by a period of rest for 3 minutes. The total period of treatment is 45 minutes daily. A moist, antiseptic dressing and a supporting bandage are applied and remain in position until the next treatment. Under suction properly applied, the breast turns a dark red, remains warm, and the whole breast enters the cup. During the earlier stages 30 to 60 c. c. of pus mixed with blood and serum and milk can be evacuated; the discharge steadily decreases until serum alone is obtained. The following precautions must be observed in applying the suction: The suction must be gentle and

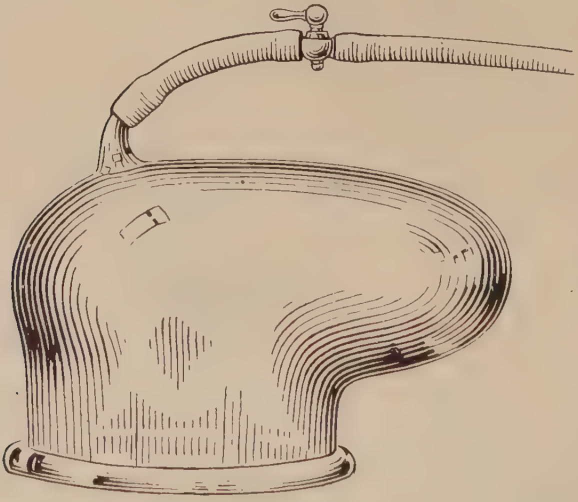


FIG. 7.—BIER'S MAMMARY SUCTION CUP. The glass trap is to catch the fluids so that they will not be drawn into the pump.

painless, the breast red and warm, not blue and cold; removal of the suction should be followed by a reactive hyperemia; no ecchymotic spots should appear in the skin. It is claimed that with this treatment a cure with a minimum of disfigurement and glandular destruction can be obtained in a shorter time than by the older methods.

(3) *Large Anterior Radiating Incisions.*—This method, which is disfiguring and very destructive of gland tissue, is reserved for the severe case in which prompt and energetic treatment is required.

(4) *Morestin's Areolar Skin Incision.*—The areolar skin incision is used in the esthetic treatment of abscess of the breast, there being no other indication than an esthetic one to justify it. This method is applicable to a superficial areolar abscess and to a collar-button abscess pointing in the areola, or one that can be reached from the areola. Following is Morestin's description:

> "During lactation the areola is 2 to 3 cm. wide. The incision starts at the root of the nipple and proceeds by the shortest route toward the abscess. The skin incision halts at the areolar margin, the knife being then carefully passed under the skin and the abscess opened to the bottom. The cavity is explored with the finger and the communication between the deep and superficial abscess made into one. The cavity is cleaned out and disinfected with the tincture of iodin or formal. A large soft rubber drain is brought out through the areolar wound. In mastitis following lactation, the breast is voluminous and more or less pendant. Thus in reality the areola is in a dependent position. Drainage is stopped in three to five days and a complete cure can be obtained in ten to twelve days."

COMPLICATIONS.—Troublesome bleeding can be controlled by packing. If sinuses have formed, they should be laid bare, traced to their source, curetted, disinfected, and packed; excised; a wedge-shaped portion of the breast containing the sinuses resected; and in cases where the breast is completely disorganized, amputation will be required. Deaths from fat emboli have been reported. Shields describes a case of acute mania accompanying a mammary abscess. We have had two such cases, in one of which the patient took her own life.

NON-TUBERCULOUS CHRONIC ABSCESS.—Any acute abscess may become chronic. The inframammary and retromammary types are most often encountered. Inframammary abscesses occur most frequently in women past middle life. They result from infected hematomas, the suppuration of cysts, or the lighting up of a residual abscess. The retromammary type is most often the result of conditions arising without the breast (see page 632). Chronic abscesses derive their surgical significance from the difficulties and mistakes made in diagnosing them. Such abscesses are often mistaken for tumors, cancer, cysts, tuberculosis, etc. The fact that a bloody discharge may be obtained from the nipple, that the nipple may be retracted, that the thick-walled abscess may simulate a tumor, and that axillary glandular enlargement is present, makes an accurate diagnosis absolutely essential.

The treatment consists in removing the abscess intact. The abscess is exposed preferably by the thoracomammary incision; the breast is turned up and the abscess dissected out in its entirety. If conditions prevent this, the abscess is incised, disinfected, and efficient drainage provided. At times amputation of the breast is required.

Chronic retromammary abscess arising without the breast is treated by incision, drainage, and the removal of the causative factor.

6. **Gangrenous Cellulitis (Diffuse Phlegmon).**—Gangrenous cellulitis of the breast is treated on the same principles as any gangrenous cellulitis.

7. **Ligneous Phlegmon.**—This term has been applied by Ombrédanne to a condition in the breast that corresponds to that described by Reclus as ligneous phlegmon of the neck, or by the Germans as Holz phlegmone. It is characterized by a slow course and a wood-like hardening of the tissues. The condition may persist for months, but as a rule terminates in resolution or gives rise to a chronic mastitis.

The treatment consists in the establishment of an accurate diagnosis, an improvement in the patient's general condition and in local means to stimulate the activity of the tissues. The latter consists in the employment of support, compression, compound iodin ointment, mercurial ointment, etc., and the judicious use of Bier's suction cups.

Chronic Mastitis

Chronic inflammation of the breast, or chronic mastitis, is characterized by the increase in the connective tissue and the gradual destruction of the glandular elements. The most important part played by the surgeon is the securing of an accurate diagnosis, the prevention of anything that might irritate the breast, and the treatment of any associated genital affections.

The use of bandages, iodin, ointments, and other local applications should be limited, as a continuous use may start a chronic irritation.

TUBERCULOSIS OF THE BREAST

Primary tuberculosis of the breast is rare. With the few exceptions of direct inoculations of the breast, the tuberculosis is secondary to lesions elsewhere. This fact brings into prominence the necessity of the general treatment of the patient. The skin is adherent in 70 per cent. of the cases, the nipple retracted in 30 per cent., and 50 per cent. of the cases show an early axillary involvement; fistulization is not uncommon.

Palliative Treatment.—This consists in the use of the quartz lamp, X-rays, and heliotherapy. These procedures are to be combined with the appropriate surgical treatment of the existing sinuses and pus collections. The peculiarities of surgical tuberculosis and the liability of such lesions to secondary infection are to govern the surgical interference. The value of tuberculin for this condition has yet to be proved. Provided the tuberculous lesion is clearly limited to a small area, a partial resection of the gland may be performed. This method is advocated by Rodman in cases of young unmarried women in whom a mutilation of the breast would impair chances of matrimony.

Radical Treatment.—The radical treatment, which is best, consists in amputating the breast and removing the axillary glands.

Prognosis.—Provided all the disease is removed and the axilla cleaned out, the operative treatment of the primary cases offers a permanent and satisfactory cure with little or no mortality. Recurrences however have been reported. In the secondary cases, the prognosis is modified by the nature and extent of the original lesion. Deaver reports a series of 45 primary cases and 29 secondary ones treated by operation without a death. Broendle, reviewing the late results obtained in 16 operative cases in the Tübingen Clinic, reports but one recurrence. This was a severe case with secondary involvement of the ribs. In the cases where the radical operation was performed, the percentage of cures was 93.7 per cent.

SYPHILIS OF THE BREAST

The treatment of syphilis of the breast presents no special differences from the treatment of syphilis elsewhere in the body.

ACTINOMYCOSIS OF THE BREAST

This rare condition may be the result of a direct infection through a crack in the nipple or skin, or may be secondary to an abdominal or thoracic actinomycosis. The obstinate character of the suppuration and its tendency to develop metastases, necessitate prompt and energetic treatment. Locally it is best combated by a wide excision or an amputation of the breast; internally, by the administration of potassium iodid.

HYDATID DISEASE OF THE BREAST

Hydatid cysts of the breast are rare. They may be situated in the breast, in tissue behind the breast, or in the pectoral muscle. The best method of treatment consists in the excision of the cyst with the adjacent glandular tissue by a wedge-shaped resection. Other methods are incision of the cyst, evacuation of its contents, removal of the parent cyst and amputation of the breast.

GALACTOCELE

Galactoceles are cysts containing milk or substances derived from milk. As a rule, they are found near the nipple, but they may occur anywhere in the breast. The treatment is excision of the sac and immediate suture of the wound. In rare instances amputation of the breast has become necessary. We consider both aspiration and incision of the cyst unsurgical procedures.

KELOID OF THE BREAST

The best results seem to have followed the use of radium, X-rays, and the high-frequency spark. Operative results have been disappointing and recurrences common. In operating, a wide excision should be made and the gap filled in with skin grafts. Injections of thiosinamin are employed. Smyth (50) recommends repeated injections of small amounts of 40 per cent. formalin into the substance of the keloid, claiming that in a few weeks the keloid is destroyed by dry necrosis. The formalin must not be injected in the subcutaneous tissue.

CYSTIC DISEASES OF THE BREAST (RECLUS)

Chronic Cystic Mastitis (*Koenig*); *Cystadenoma of the Breast* (*Schimmelbusch*); *Abnormal Involution* (*Warren*); *Senile Parenchymatous Hypertrophy* (*Bloodgood*); *Fibrous and Glandular Hyperplasia with Retention Cysts* (*Whitney*)

Cystic disease of the breast is a senile lesion of the breast usually beginning at or a short time before the menopause, although it sometimes occurs in younger women. The condition is at first clinically benign and may remain so, or it may undergo malignant degeneration. The proportion of cases undergoing this change is variously estimated at 10 to 50 per cent., a more just estimate being from 12 to 15 per cent. Of the different types, the adenocystic shows the greatest tendency to become malignant.

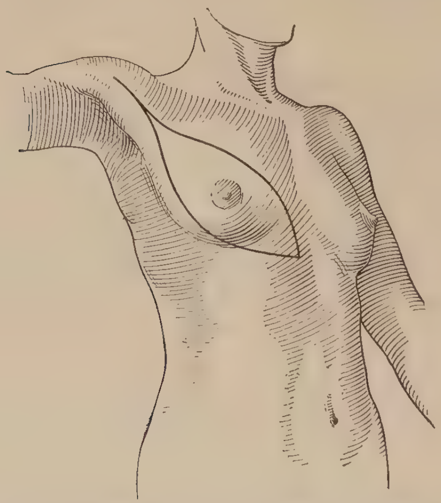


Fig. 8.—Incision for Amputation of Breast for Chronic Cystic Mastitis. Incision extends on to the shoulder far enough to dissect flaps for axilla. (Judd.)

The treatment consists in (1) a conservative amputation of the breast with the axillary glands and fascia; (2) simple amputation of the breast by the anterior elliptical incision; (3) plastic excision of one or both breasts by means of the Thomas semilunar thoracomammary incision; (4) plastic resection of the breast, which may be justified in rare instances where the disease is localized in a portion of the breast; it should, however, not be employed as a routine procedure; Rodman favors the method employed by Warren.

(1) Conservative Amputation of the Breast with the Axillary Glands and Fascia (Judd's Operation).—This operation (Figs. 8, 9, 10, 11) is preferred in all cases of cystic mastitis in which a clinical or pathological diagnosis of malignancy cannot be made. If the slightest suspicion of malignancy is entertained the radical operation for carcinoma is performed (Figs. 12, 13).

TECHNIC.—Make an oblique elliptical incision as in Figure 8. The breast and pectoral fascia are freed from the underlying muscle and retracted outward (Fig. 9). Retract the intact pectoralis major upward and inward. Remove the axillary fascia and glands, and as much as possible of the fascia lying between the pectoralis major and minor (Fig. 10). Make a stab puncture in the axillary flap and drain with split rubber tube; insert a second tube at the lower angle of the wound (Fig. 11). Close the wound with interrupted silkworm-gut sutures, approximating the edges with a continuous horsehair suture. This operation allows of a thorough conservative removal of the breast, pectoral and axillary fascia, along with the axillary glands, without the inconvenience and risks attendant on the more radical operation for carcinoma.

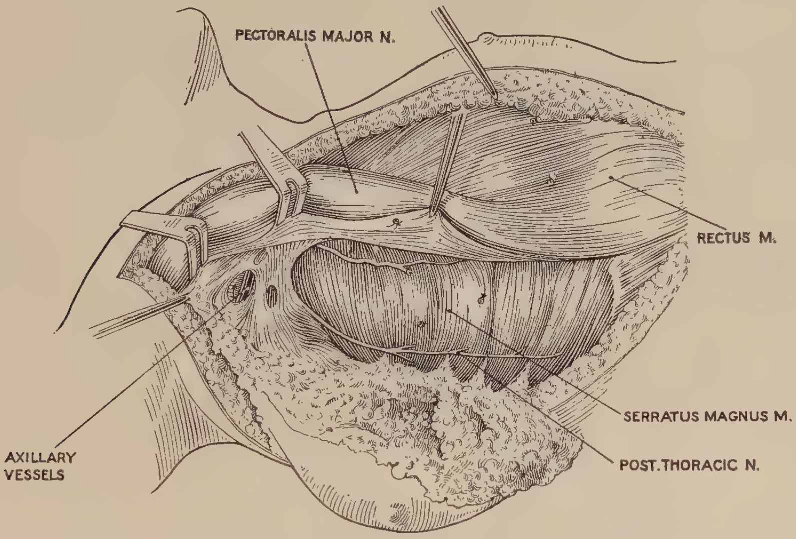


FIG. 9.—PECTORALIS MAJOR PRESERVED BUT REFLECTED. Fascia has been dissected from muscles and chest wall. Breast turned down exposing axillary fascia and glands. (Judd.)

(2) **Simple Amputation of the Breast by an Anterior Elliptical Incision.**—With the arm abducted, make an oblique elliptical incision over the breast, including the nipple. Starting above, the incision runs obliquely downward and inward, extending between the corresponding limits of the gland. The skin is dissected free from the breast, the pectoralis major exposed, and the breast removed from it. The wound is closed by interrupted sutures.

COMMENT.—This operation is easier to perform, more thorough, and gives a better exposure than the plastic excision, but is more deforming.

(3) **Plastic Incision of One or Both Breasts by Means of the Thomas Semilunar Thoracomammary Incision** (Fig. 14).—Make a semilunar incision in the

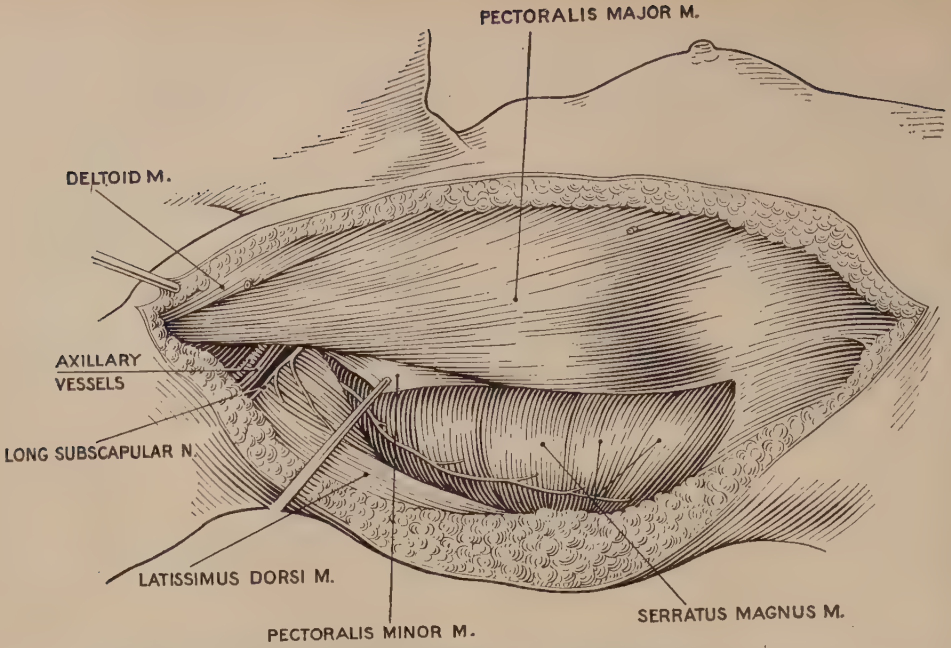

PECTORALIS MAJOR M.
DELTOID M.
AXILLARY VESSELS
LONG SUBSCAPULAR N.
LATISSIMUS DORSI M.
PECTORALIS MINOR M.
SERRATUS MAGNUS M.

Fig. 10.—Axillary Dissection Completed; Vessels and Nerves Exposed. Fascia from between the pectoralis major and minor removed as completely as possible. (Judd.)

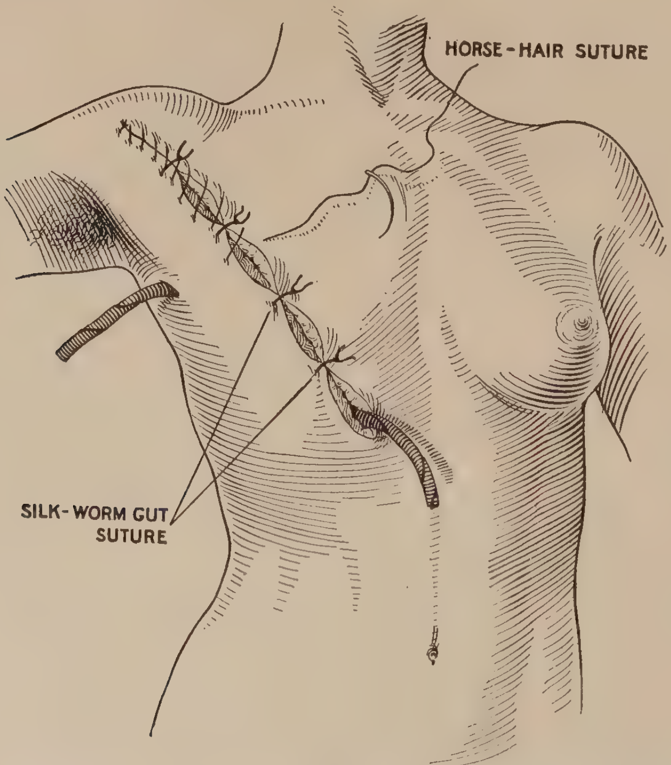

HORSE-HAIR SUTURE
SILK-WORM GUT SUTURE

Fig. 11.—Showing Closure of Incision, with Two Points of Drainage, After the Conservative Operation. (Judd.)

external thoracomammary fold, parallel to the outer edge of the external hemisphere. This gives a better exposure than the classical incision of Thomas. As a preliminary to the operation, the incision should be carefully marked out with carbol-fuchsin while the patient is in the erect position. If the breast is movable and the incision is made in the prone position, the surgeon will be chagrined to find that his seemingly well-planned scar will become visible when the patient resumes the erect position. Carry the incision down to the outer edge of the pectoralis major and expose the deep layer of the pectoral fascia which covers the posterior aspect of the gland and is separated from the deep layer of the pectoral fascia by loose connective tissue. By blunt dissection separate the gland from the muscle. Turn the breast upward and inward toward the sternum so that the posterior surface faces anteriorly, the breast being made prominent by the left hand forcing the posterior surface forward. Dissect the gland from the skin, taking care to prevent buttonholing of the skin and damage to the nipple. Check all bleeding. To prevent the sinking of the nipple, pull it forward and insert a loose purse-string suture of catgut on the internal aspect of the areola. Provide suitable drainage, close the wound

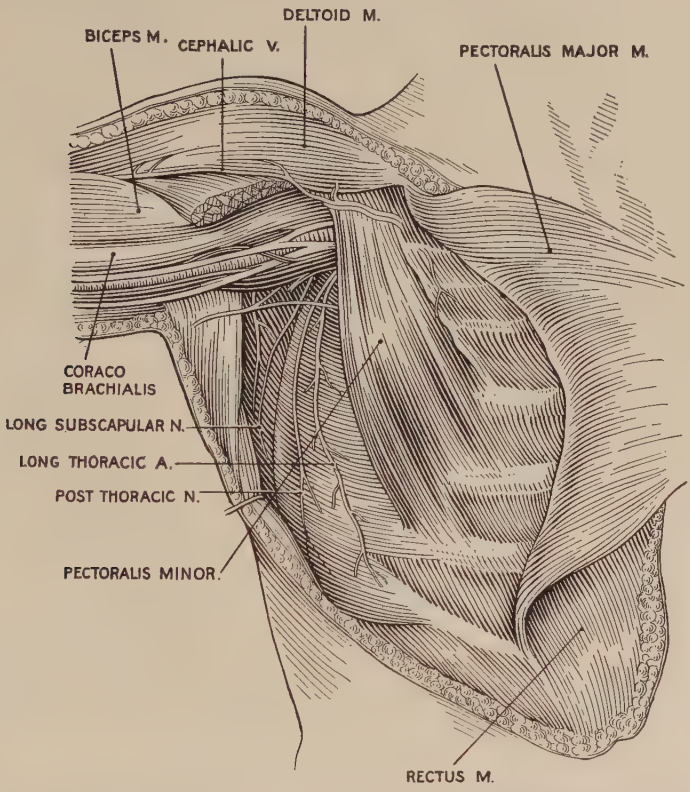


Fig. 12.—Anatomic Dissection, Showing Exposure of Axilla, Obtained by the More Radical Procedure of Removal of Muscles and Fascia. (Judd.)

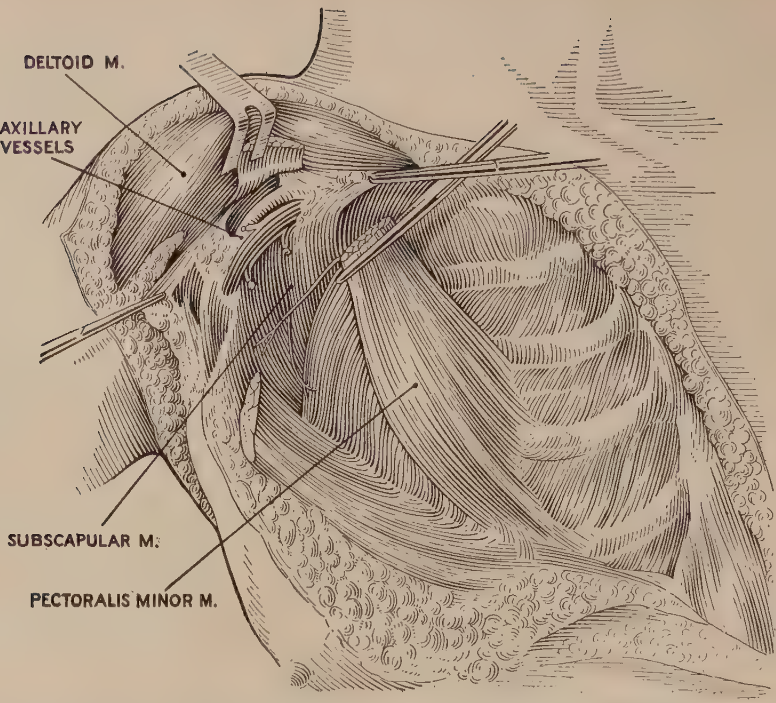

DELTOID M.
AXILLARY VESSELS
SUBSCAPULAR M.
PECTORALIS MINOR M.

Fig. 13.—Pectoralis Major, Breast and Fascia Turned Down and Insertion of Pectoralis Minor Cut Off From Scapula. Fascia and glands lying underneath this part of the pectoralis minor exposed. (Judd.)

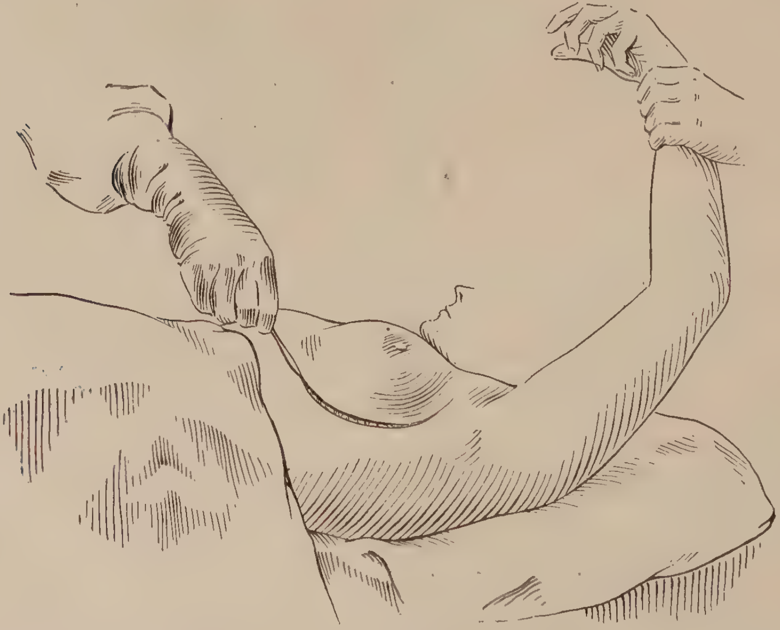


Fig. 14.—Crescentic Incision in the Thoracomammary Fold. (Thomas' incision.)

with interrupted sutures, apply a dry dressing, and secure it with a Warren supporting bandage.

COMMENT.—The disfigurement is slight, the nipple is retained, and the scar falls in the thoracomammary fold. Iodin should not be used in the preparation for this operation, as it may interfere with the nutrition of the delicate breast skin. In drawing the nipple forward it should be gently handled; a hemostat should never be used for this purpose. The depression left by the removal of the gland can be filled in by a graft of fat taken from the abdomen or buttock. Lipomata have been used for this purpose. Even though no tissue is transplanted, it is remarkable to observe how well the depression fills in. The improvement can be materially hastened by a systematic massage.

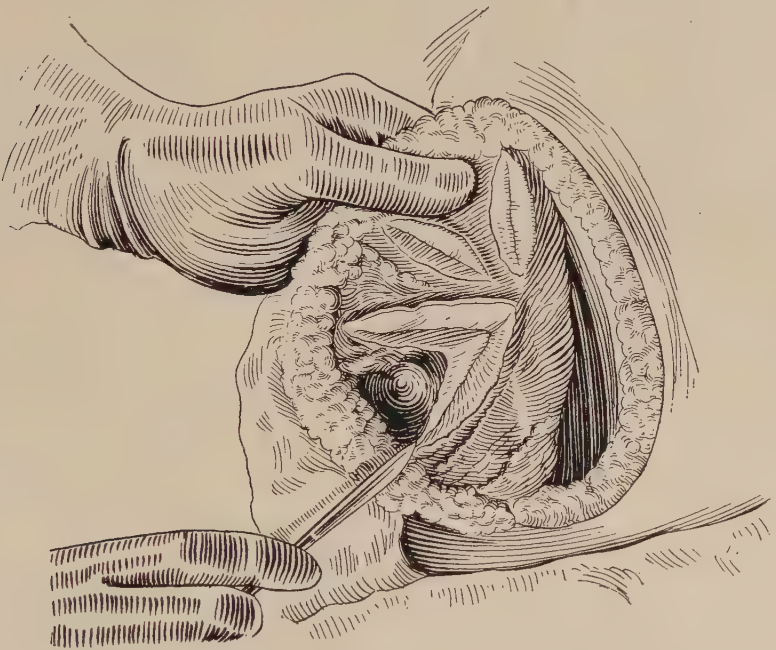


FIG. 15.—PLASTIC RESECTION. Removal of wedge-shaped piece containing cysts. Radiating incisions in the other lobules. (Warren.)

(4) **Plastic Resection of the Breast (Warren).**—Warren's operation (Figs. 14, 15, 16, 17) is made possible by the fact that the main blood supply of the breast is on the anterior surface of the gland and in the anterior position (see page 616). We believe that this operation is an ideal one for benign tumors, isolated cysts, etc., but it is not indicated in cystic diseases of the breast, basing our opinion on the fact that in many cases it is practically impossible to discover and remove all the cysts by this method. As the operation has for its chief object the prevention of the possibility of malignant degeneration of the cysts, amputation of the breast is preferable to a plastic resection.

Plastic resection of the breast was first suggested by Gaillard Thomas (1882) and improved upon by Warren (1902).

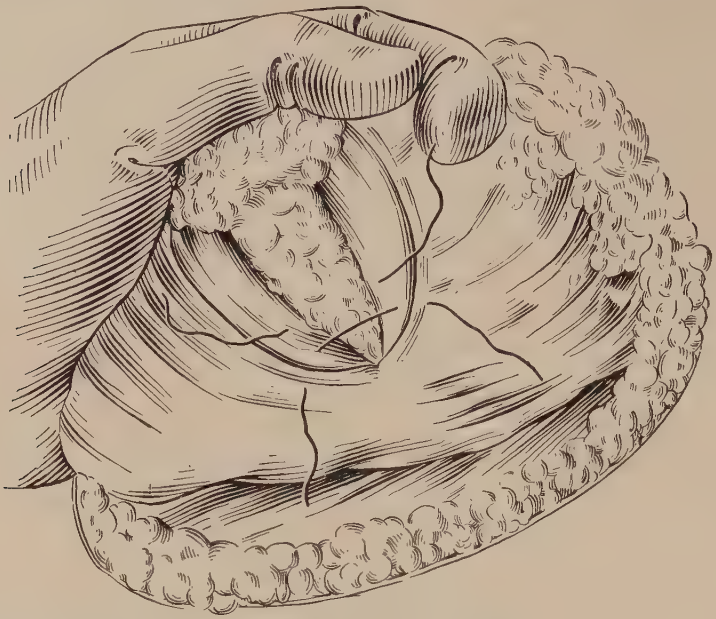


Fig. 16.—Plastic Resection. Reconstruction of breast with buried sutures. (Warren.)

The posterior surface of the gland is exposed as in the plastic excision. Inspect and palpate the gland tissue for the presence of cysts, etc. Usually one or more cysts are found in the same quadrant. Remove these by excising

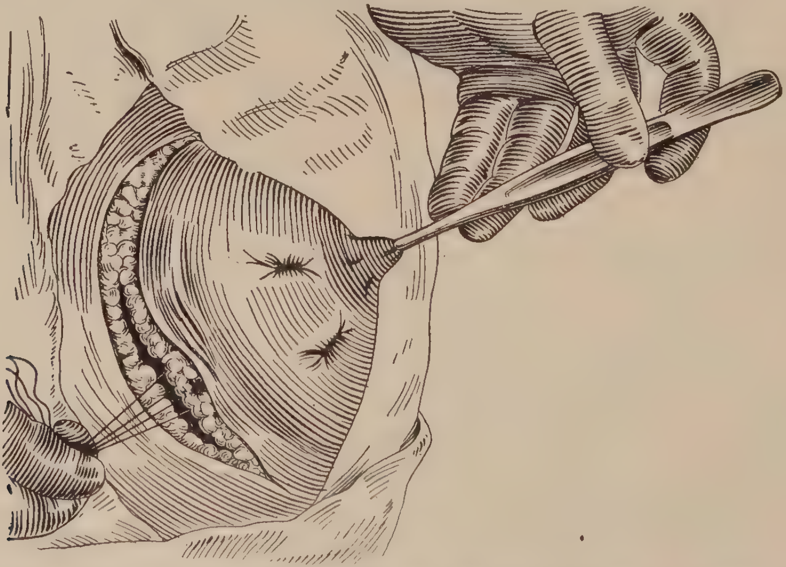


Fig. 17.—Plastic Resection. Reconstruction of the breast with buried sutures. Eversion of nipple. (Warren.)

a wedge-shaped portion of the breast tissue, the apex of which is turned toward the center of the gland, the base toward the periphery. Carry the knife forward to the adipose tissue; do not remove this latter, however, as it plays an important rôle in preventing subsequent depression. From the center of the breast carry radiating exploratory incisions toward the periphery. The cysts thus exposed are bisected or snipped out with a scissors. Arrest all hemorrhage, prevent regression of the nipple as in plastic excision of the breast, close the wedge-shaped incision by a double layer of catgut sutures, drop the breast back and anchor it to the outer edge of the pectoralis major. Introduce a small rubber tube drain, close the skin with interrupted silk sutures, and secure the dressing in place with a Warren's supporting bandage (Fig. 18).

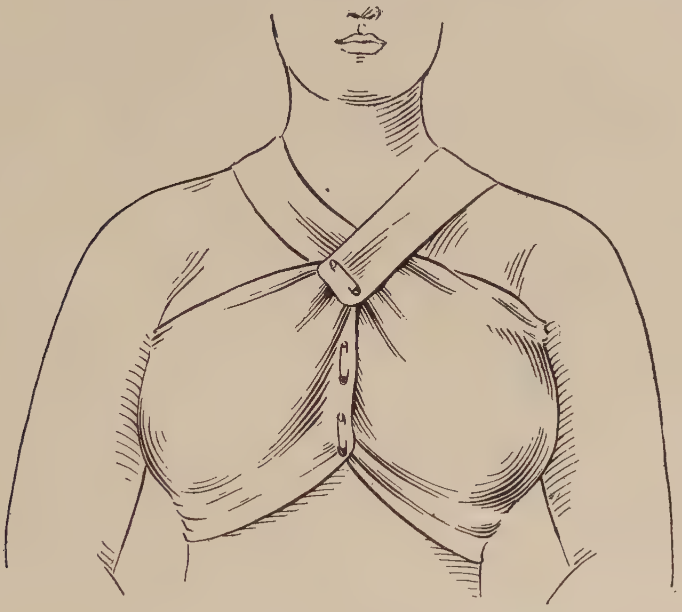


FIG. 18.—WARREN'S SUPPORTING BANDAGE.

CLASSIFICATION OF CYSTS

Cysts may be classified as follows: retention cysts (see Galactocele, page 637; simple cysts; cysts with intracystic papillomatous growths; dermoid cysts; hydatid cysts (see Hydatid Disease, page 637); cancer cysts (see Cancer); and cysts developing in malignant growths (see Cancer).

Simple Cysts.—Simple cysts are to be excised together with a portion of the gland. The surgeon must assure himself that there is no infiltration of the wall and that the contents of the cyst are not bloody. The excision is best performed by Warren's plastic method. Multiple cysts demand an amputation. Aspiration and injection of cysts are mentioned to be condemned.

Cysts with Intracystic Papillomatous Growths.—The entire breast should always be removed and a frozen section made. If the microscope fails to reveal anything and the base of the papillary growth appears to be infiltrated, proceed as in carcinoma and perform the radical operation. It is extremely difficult at times to detect the shading over into malignancy.

Dermoid Cysts.—Small dermoid cysts should be completely excised; if large, or of long standing, the breast should be amputated.

BENIGN TUMORS OF THE BREAST

Benign tumors of the breast include lipoma, angioma, enchondroma, endothelioma, and the fibro-epithelial tumors. We agree with Bloodgood that "only by recognizing conditions in the precancerous stage can the fatal incident of cancer be greatly reduced. **We regard every breast tumor as potentially malignant and advise immediate removal.**" We prefer, in the majority of cases, an amputation to a plastic resection and reject every form of medical treatment as being worthless and often leading to dangerous delays.

Lipoma.—Single or multiple subcutaneous lipomata are excised; the inframammary and retromammary lipomata are treated by plastic resection.

Angioma.—Mammary angiomata are treated by excision of the breast. Areolar or subcutaneous angiomata are treated by the excision of the diseased tissue, or by the application of radium, liquid air, etc.

Enchondroma (Mixed Tumor).—Amputation of the breast is indicated with dissection of the axilla if the glands are enlarged.

Endothelioma.—This rare tumor shows a tendency to recurrence unless a thorough total extirpation is performed.

Fibro-epithelial Tumors.—These should be removed, and the safest procedure in the majority of cases lies in the amputation of the breast. A single small fibro-adenoma can be treated by excision. If there is a tendency to rapid growth, amputate the breast.

Periductal Fibroma and Myxoma.—Periductal fibroma and myxoma call for prompt excision of the breast. Advanced cases require in addition the removal of the pectoralis major and the axillary glands. The treatment of a small adenofibroma is excision of the growth with its capsule. Larger growths require amputation. Benign fibro-epithelial tumors do not recur after a complete removal.

SARCOMA OF THE BREAST

The operation for sarcoma is done in exactly the same way as for carcinoma. Accumulated clinical experience has shown that sarcoma invades the lymph vascular system very nearly as quickly as carcinoma, and that no reliance can be placed in the supposed absence of glandular involvement. **It is a dangerous delusion and an unsurgical procedure to amputate the breast without clearing the axilla.**

Exploratory Operations on the Breast.—In performing an exploratory operation for suspected cancer the tumor should be removed with a portion of surrounding breast—or better the whole breast. The actual cautery is applied to raw areas, or the cavity packed with gauze soaked in Harrington's solution. The suspected tissue should be closely inspected and frozen sections made for microscopic examination. In the majority of cases a diagnosis can be made on the gross appearance of the tissue.

The Two-stage Operation on the Breast.—In the first stage the tissue is removed for microscopic examination and the wound closed. Later, at the second sitting, the complete operation is performed. **This is an unsurgical procedure, and in the face of a possible malignancy is wantonly courting disaster.**

CARCINOMA OF THE BREAST

History of the Operation for the Cure of Mammary Carcinoma.—As early as the third century Antyllus operated for cancer of the breast. The breast was seized with great pincers, swept off with the knife, and the raw surface seared with the cautery—the ancients thus antedating our forefathers in surgical thoroughness. Benjamin Bell (1804) taught that the removal of the axillary glands with the pectorals down to the ribs was absolutely necessary in the treatment of cancer. Sir Astley Cooper advocated a wide removal of the skin over the cancer and the channels leading from the breast, whether they appeared to be involved or not. The carrying out of such heroic measures without the benefits of anesthesia and antiseptics required a stout heart. By many it was held that the results obtained did not justify the terrible suffering entailed. An added factor in pessimism was the general belief that cancer was a constitutional disease and could not be cured by local means. Sir Astley Cooper himself stated that the complaint is in part constitutional and in part local.

Charles Moore (31), a surgeon of Middlesex Hospital, London (1867), shattered the constitutional theory of cancer and is undoubtedly the father of the modern operation. According to Handley, Moore's teachings found but little favor outside the Middlesex Hospital. Moore insisted that the entire breast and all the involved structures, skin, fat, pectoral fascia, pectoral muscle, and enlarged lymphatic glands should be removed in one block, and that this be done without cutting into or seeing the growth.

Sir Mitchell Banks of Liverpool (1882) advocated "the removal of the axillary glands, as well as the breast, in all cases whether we can feel them enlarged or not." Banks had practiced this since 1878. According to Rodman, Gross, "in the late seventies, began to teach and practice the principles laid down by Moore." Halsted in 1892 practiced the removal of the supraclavicular glands. Volkmann (1882) instituted the routine removal of the fascia covering the pectoralis major. Banks (1867) advocated the removal of the pectoralis major when involved; Halsted (1888) practiced it as a routine and succeeded in convincing the profession of its necessity. He states (1894) that "the entire pectoralis major or all except its clavicular portion, should be excised in every case of cancer of the breast."

To Willy Meyer of New York (1894) belongs the credit of urging that both pectorals be removed, and that the dissection of the lymphatics precede the removal of the breast. Meyer's operation was devised entirely independently of Halsted. In 1904 Handley, of London, put forward his theory of the permeation of the cancer cells, and advocated a much wider removal of the deep fascia. He removes the fascia covering the inner border of the opposite pectoral, the upper portions of the rectus, and external oblique and that of the latissimus dorsi. Stiles (1892) made valuable contributions to the surgical anatomy of the breast, showing that the breast tissue was far more extensive than had been previously taught. His work greatly enhanced the value of the "complete operation."

Operative Indications.—Provided the patient's general condition warrants it, the radical operation should always be performed, even if the hope of a permanent cure is remote. Age is not a bar; the older the patient, provided she stands the shock of the operation, the better the chance of cure. No definite rules can be laid down for palliative operations. Each case must be judged on its own merits. The operation should only be undertaken with the object of prolonging the patient's life or for the relief of the mental and physical agonies occasioned by the presence of a foul carcinomatous ulcer.

Contra-indications.—(1) Acute inflammatory cancer (mastitis carcinomatosa of Volkmann).

(2) Cancer en cuirasse.

(3) When the tumor is associated with multiple carcinomatous nodules in the skin.

(4) When the tumor is firmly fixed to the chest wall.

(5) When the cervical or axillary glands are so extensively involved that a radical operation cannot be performed and when no benefit is expected to be derived from a partial operation.

(6) In elderly patients with long-standing atrophic or diffuse cicatrizing carcinoma.

(7) In the presence of visceral or bony metastasis.

The frequency of pulmonary, hepatic, bony, and spinal metastasis is to be kept constantly in mind. It may be clinically impossible to detect early involvement of these structures. All complaints of gastric disturbances, neuritis, pains in the bone, rheumatism, etc., are to be carefully investigated and radiographic examinations made.

Remarks on Operations for Carcinoma of the Breast.—The operation consists in the removal of the breast and all the tissues which have been shown by anatomical, pathological, or clinical investigation to be potential cancer channels. We accept as a working basis Handley's theory of cancerous permeation and add to the radical operation the additional routine step of removing the subcutaneous tissue and the aponeurosis of the recti from the epigastric triangle. We believe in the advantages of Willy Meyer's method of attacking the axilla before removing the breast. The hemorrhage is diminished, the danger of expressing cancer cells into neighboring or remote tissues is to a large extent avoided, a clearer field is obtained, and the extensive exposure of the chest is delayed until the terminal stage of the operation. In clearing the axilla, after ligating the vessels and exposing the nerves, all work should be done outside the fascial boundaries and the fascia removed in planes. The old method of merely brushing, stripping, or dissecting out the contents within the axilla should not be employed.

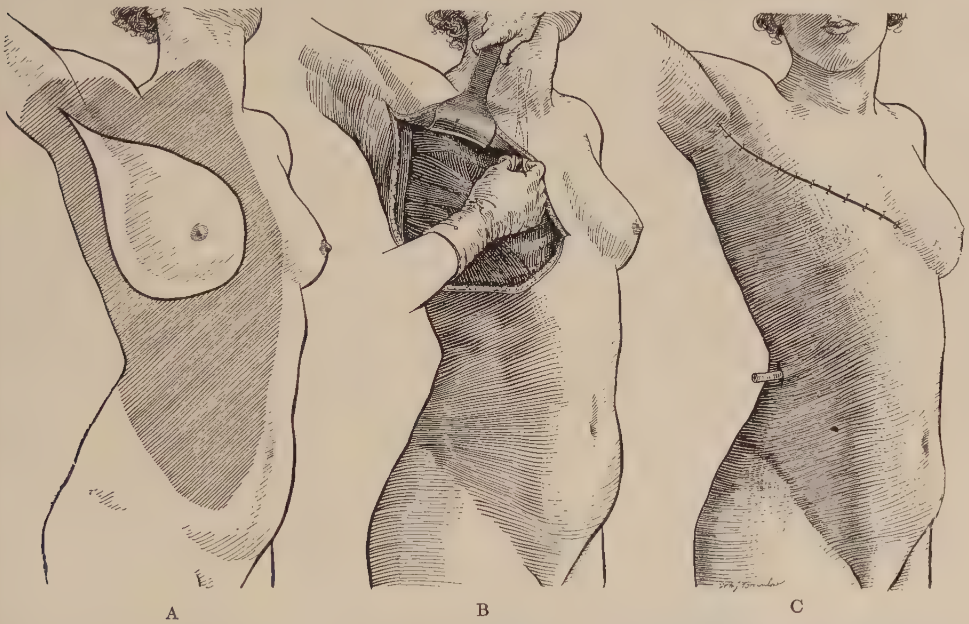


Fig. 19.—Morestin's Incision. A—Continuous line shows the area of skin to be removed. Shaded area shows undermining of flaps. B—Method of mobilizing the integument of the neck. C shows the method of closure after mobilization of the skin over the neck and abdomen. Drainage tube at the lowest point of undermining.

THE SKIN.—A wide, circular removal of the skin and subcutaneous tissue combined with an extensive undermining according to the Morestin principle (Fig. 19) is performed. Rodman attributes the excellent results obtained by Gross and Banks to the free removal of the skin practiced by them.

REMOVAL OF THE PERMEATED AREA OF THE DEEP FASCIA.—Handley believes that, while removal of the skin has in some hands reached the furthest possible limits without any corresponding improvement in results, it is possible to remove the deep fascia (Figs. 20, 21, A) over a wider area than is usually done. Except in very early cases the removal of a maximal circular area of deep fascia centered upon the primary growth is a step absolutely essential to the completeness of the operation. He takes the distance from the nipple to the clavicle as the radius of the circle of deep fascia around the growth which can be removed without difficulty by undermining the skin flaps and prolonging the incision downward. If the growth starts under the nipple, the deep fascia is removed superiorly to the clavicle and inferiorly to a horizontal line running 2 in. beneath the tip of the ensiform cartilage; internally 1 to 2 in. beyond the middle line, and externally just beyond the anterior edge of the latissimus dorsi.

It has been suggested that the bad results obtained in growths situated near the margins of the breast may be due to the fact that not enough of the infected fascia is removed. In cancer situated at the sternal margin it may be necessary to remove the deep fascia from beneath one half the opposite breast, if, at the lower margin of the breast, the abdominal deep fascia should be removed to the umbilicus, or if, in the axillary tail, the fascia over the deltoid and on the posterior surface of the latissimus dorsi must be removed.

REMOVAL OF MUSCLES.—It is necessary to remove the whole of both pectorals with the exception, in early cases, of clavicular fibers, the digitations of the serratus magnus lying in contact with the breast, and the superficial layer of the external oblique which arises from the fifth and sixth ribs.

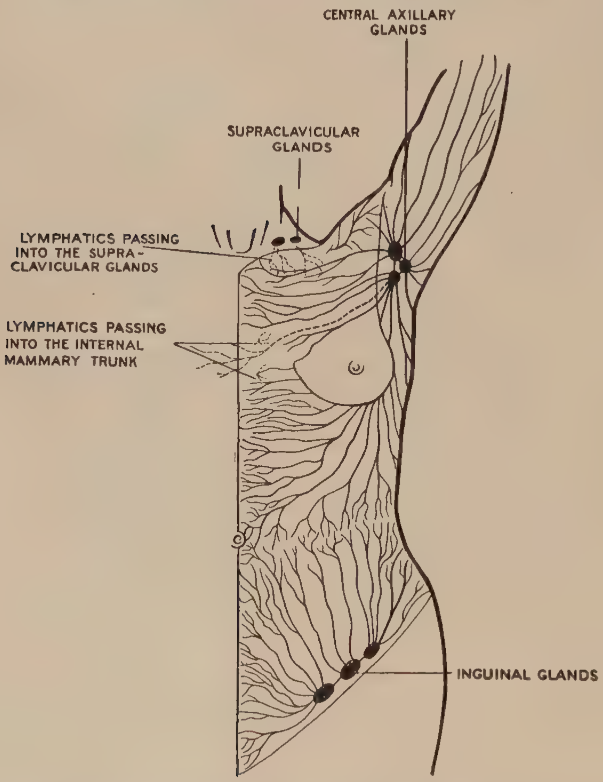

CENTRAL AXILLARY GLANDS
SUPRACLAVICULAR GLANDS
LYMPHATICS PASSING INTO THE SUPRA-CLAVICULAR GLANDS
LYMPHATICS PASSING INTO THE INTERNAL MAMMARY TRUNK
INGUINAL GLANDS

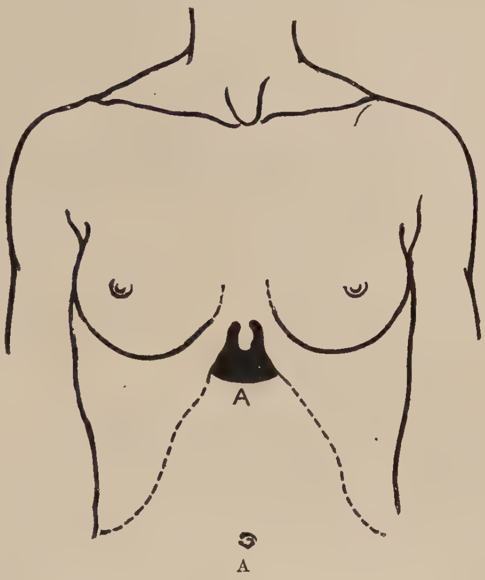
FIG. 20.—LYMPHATICS OF THE ANTEROLATERAL PORTION OF THE THORAX AND ABDOMEN. (After Poirier and Cuneo.)

The Operation.— PREPARATION OF THE PATIENT.—This is the same as for any other operation of similar magnitude. In preparing the skin we rely on the older methods of disinfection and do not favor the use of iodin in this situation. The iodin is irritating to the delicate breast skin, toughening it and diminishing its pliability.

ANESTHESIA.—Gas and oxygen anesthesia combined with the preliminary use of morphin is preferred. If this is unsuitable, ether is administered by the drop method or by intratracheal insufflation. Chloroform is reserved for a few rare cases in which the condition of the lungs will not admit the use of gas, oxygen, or ether.

POSITION OF PATIENT.—The patient is placed in a dorsal position with a low sand bag between the shoulders. The arm, with the elbow flexed, is placed at right angles to the body and held by the nurse. Avoid pressure on the musculospiral nerve. When the arm is held in extreme abduction, the separation between the muscular layers is difficult to make out, the axillary vein is displaced, and thus made liable to injury. Such stretching is also a fertile cause of persistent postoperative axillary pain.

GENERAL DESCRIPTION OF OPERATION.—The removal of the breast is but an incident in the operation, and in order to make the object of the succeeding steps clear, we quote the following admirable exposition from Handley:



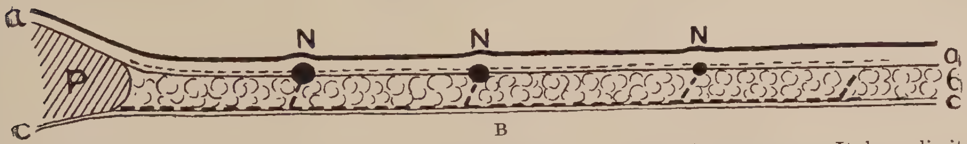


FIG. 21.—CANCER OF THE BREAST. A—The area of epigastric invasion in breast cancer. Its lower limit is a purely artificial line. This area might not inappropriately be called the dangerous area in breast cancer. B shows that subcutaneous nodules do not necessarily arise from the extension of growth along the skin. The diagram represents a section of the parietes at right angles to the surface in the region of the primary growth P; a a skin, b b subcutaneous fat, c c deep fascia. The subcutaneous nodules N N N may arise (1) from spread of growth in the skin in the direction of the lightly dotted line, a view generally held; or (2) from spread of growth in the deep fascia, along the heavy interrupted line, with occasional offshoots to the skin, giving rise to subcutaneous nodules. Though this is not the accepted view, it is the correct one in the writer's opinion. (Handley.)

"**The object of the operation should be the removal intact of the permeated area of the lymph-vascular system which surrounds the primary growth, and of the lymphatic glands which may have been embolically invaded along the trunk lymphatics of the area concerned.** How are the limits of this permeated area to be defined? It is impossible to see it with the naked eye. The operator can therefore only aim at keeping a safe distance beyond it. Of course the area of centrifugal spread in the deep fascia is not a mathematical circle, any more than is the area of spread of an ordinary case of erysipelas. Slight variations in the local conditions may lead to increased spread in one direction, to a diminished spread in another. If one or two subcutaneous nodules are present on one side of the primary growth, the skin and deep fascia on that side should be removed more widely than in the opposite direction. But in the usual absence of evidence to the contrary, the only safe assumption is that cancer has spread equally in all directions. The area of spread is circular, not not spherical, because permeation tends by preference to keep in one plane, that of the fascial lymphatic plexus (Fig. 20). But later on, permeation spreads into the small muscular and cutaneous tributaries which drain vertically into the fascial plexus and so invades the adjoining layers to a depth which reaches its maximum opposite the center of the primary growth. Thus a breast cancer with its invisible microscopic extensions forms a mass, shaped somewhat like a biconvex lens (Fig. 22). The thin circumference of the lens situated often far beyond the limits of the breast, is formed by cancer-filled lymphatics of the fascial lymphatic plexus and lies, as a rule, exclusively in the plane of the plexus. As one approaches the center of the lens which corresponds to the primary growth, the adjoining layers of the subjacent muscle on the one hand and the subcutaneous fat and skin on the other, are invaded by cancer to a gradually increasing degree."

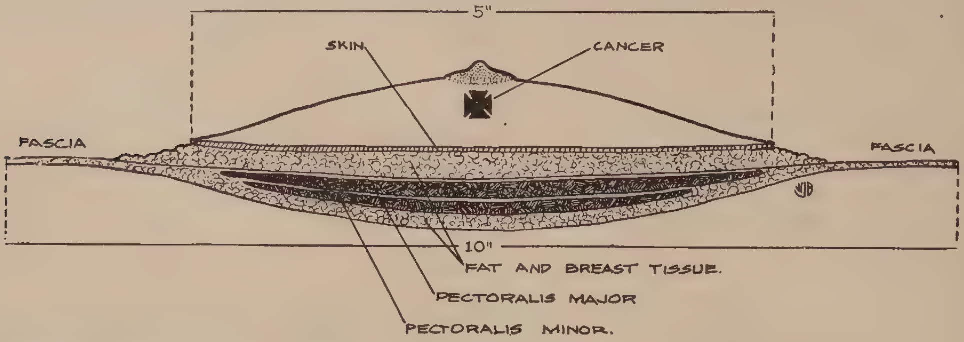


Fig. 22.—Cross-section of an Amputated Breast, Showing Relative Amounts of Skin and Deep Fascia to be Removed. Note that the greatest depth is opposite the growth.

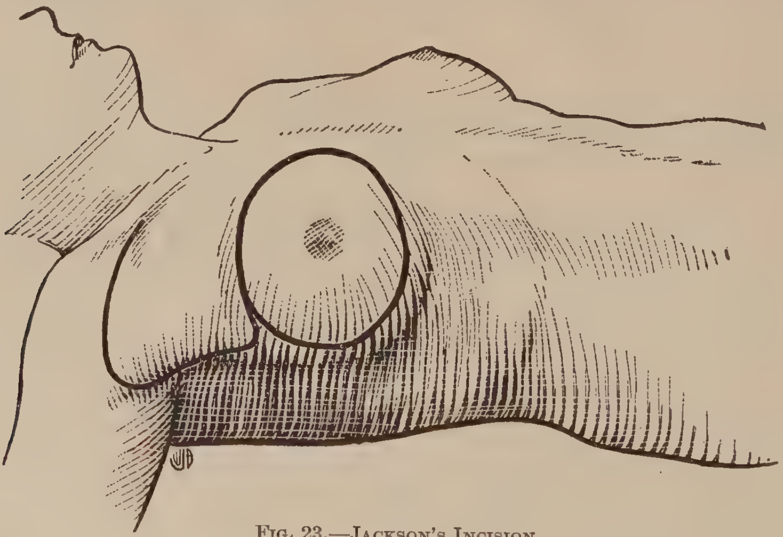


Fig. 23.—Jackson's Incision.

It will thus be seen that in the removal of the lens-shaped mass of tissue to the outer margin of which the axillary fat, glands, and fascia are attached, the removal of the breast is but an incident. The skin incision must of necessity vary with the conditions. The principal objects are the removing of a sufficient amount of skin and the providing of access to the deeper structures. Secondary considerations are the closure of the wound, the comfort of the patient, and the future usefulness of the arm. **In deciding on the amount of skin to be taken away, no regard is to be paid to subsequent closure of the wound.** We use the following incisions: Jackson's (Fig. 23), Rodman's (Fig. 24), Handley's (Fig. 25), and occasionally Kocher's and Beck's (Fig. 26). If necessary, in using Jackson's or Rodman's, we add a linear incision to the lower and inner part to provide access to the deep fascia over the epigastric triangle. The wide removal of the deep fascia mobilizes and frees the skin to such an extent that the edges of the wound can be brought together without tension, thus to a large extent abolishing the complicated flap formations and skin-grafting. Rodman's incision provides a wide removal of skin, a good access to the axilla, and a triradiate scar which does not extend to the arm. Handley's incision yields a triradiate cicatrix removed from the anterior edge of the axilla. Jackson's ingenious incision affords a good exposure and an easy closure.

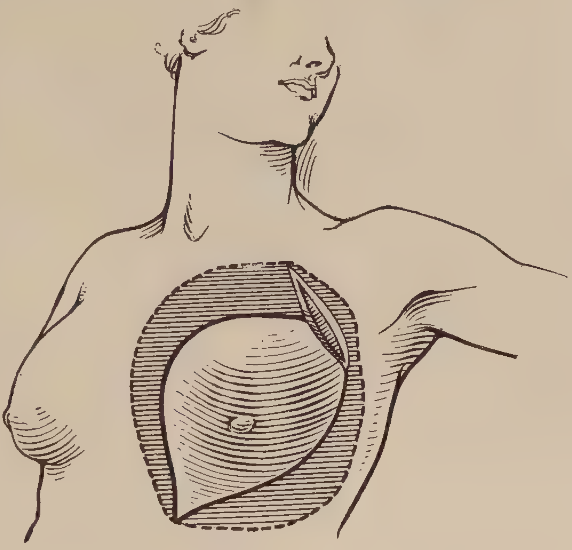


FIG. 24.—RODMAN'S INCISION. Shaded area shows undermining of flaps.

STEPS OF THE OPERATION.—I. THE INCISION (Fig. 27).—Outline the skin incision ABCDEFG. The axillary portion ABC begins at a point A, 1½ in. below the middle of the clavicle in the sulcus, marking the interval between the deltoid and the pectoralis major, and is carried down this groove to the junction of the pectoral muscle with the arm B. The incision BC is then carried down the under margin of the pectoral fold to the point C. The point D lies on the chest wall and to the outer side of the breast. The circular incision CDEG, 5 in. in diameter, has as its center the growth, not the nipple, and should be at least 3 in. distant from the tumor. The linear incision EF comes off from the lower and inner border of the annular incision and passes down the linea alba for a distance of 2 in. The incisions are to be indicated by scoring the skin. The skin incision ABC is made just deep enough to open up the subcutaneous fat without extending down to the deep fascia, the edges of the skin incision are carefully undermined, and the flap ABC is cov-

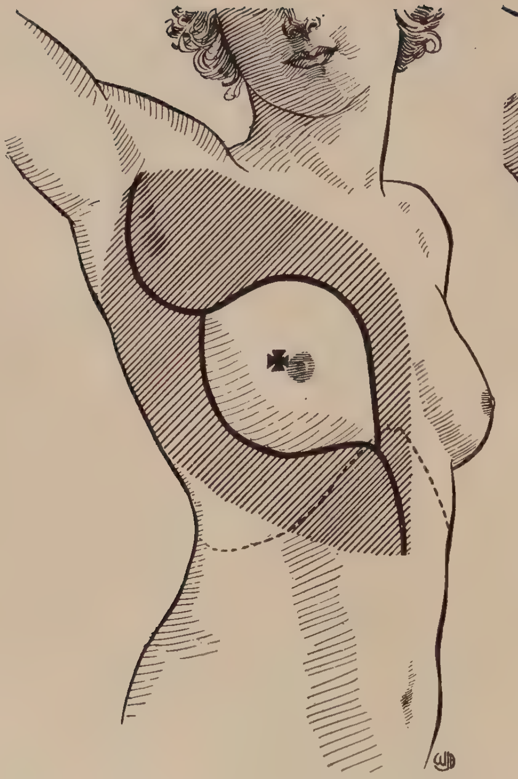


Fig. 25.—Handley's Incision. Shaded area shows fascia to be removed.

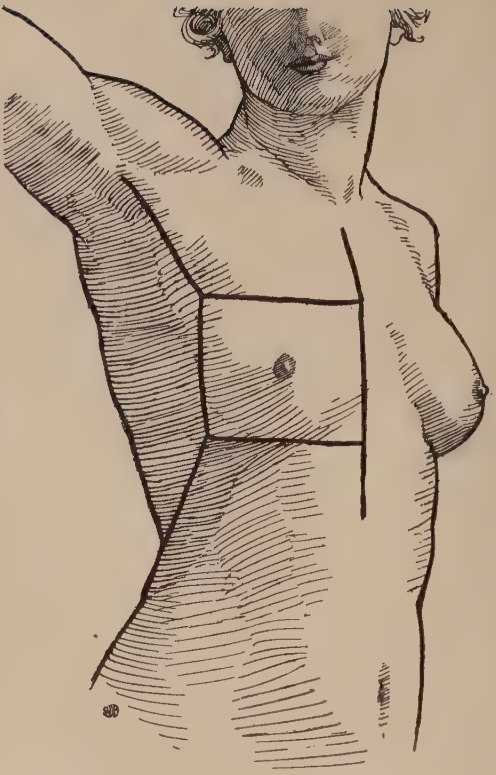


Fig. 26.—Beck's Incision.

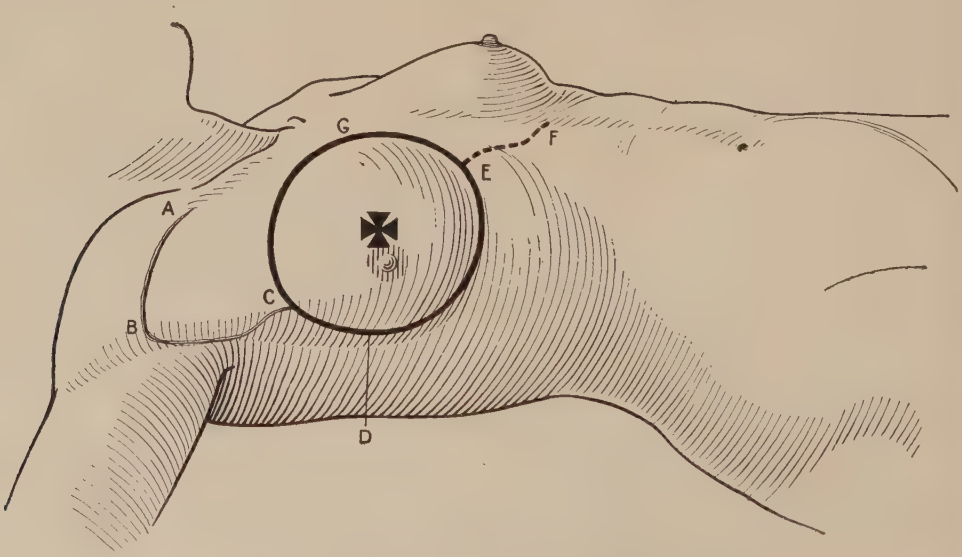


Fig. 27.—Operation for Breast Cancer. Incision.

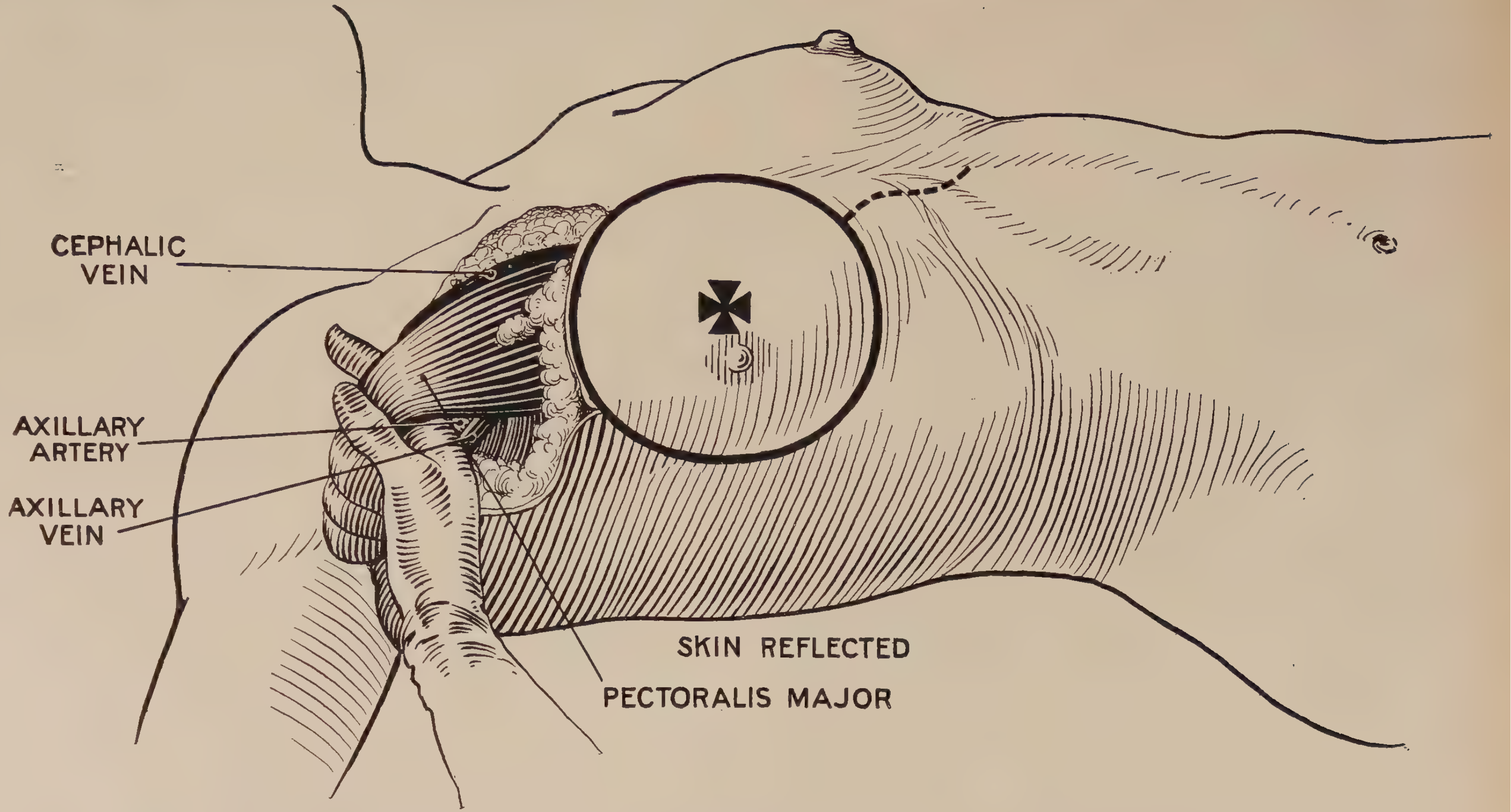

CEPHALIC VEIN
AXILLARY ARTERY
AXILLARY VEIN
SKIN REFLECTED
PECTORALIS MAJOR

FIG. 28.—OPERATION FOR BREAST CANCER. THE AXILLARY FLAP HAS BEEN FREED AND TURNED INWARD. The finger is passed under the insertion of the pectoralis major.

ered with a hot towel and turned upward and inward. Expose the tendinous insertion of the pectoralis major. Hook the index finger under the muscle (Fig. 28), divide it at its insertion, free it from the clavicle, and turn it backward against the chest. This exposes the clavicoraco-axillary fascia (Figs. 29, 30), which passes from the clavicle, invests the pectoralis minor, and from the lower border of the muscle passes downward to the skin of the axilla as the suspensory ligament (Fig. 31).

II. The Fascial Dissection of the Axilla (Figs. 31, 32, 33, 34).—Locate the axillary vessels and brachial plexus, which can be seen shining through the fascia. Do not break through the fascia, but incise it along the line of the coracobrachialis (Figs. 29, 30) up to the insertion of the pectoralis minor. Hook the finger under this latter and divide it. Place a clamp on the cut edge of the fascia and retract it toward the chest. With the gloved index finger, or by expanding a Mayo scissors underneath the fascia, strip it in one plane from the arm inward across the sheath of the vessels. In this manner the whole upper edge of the clavicoraco-axillary fascia is loosened and the vessels exposed throughout their course in the axilla and upper arm. All perforating vessels are secured and ligated.

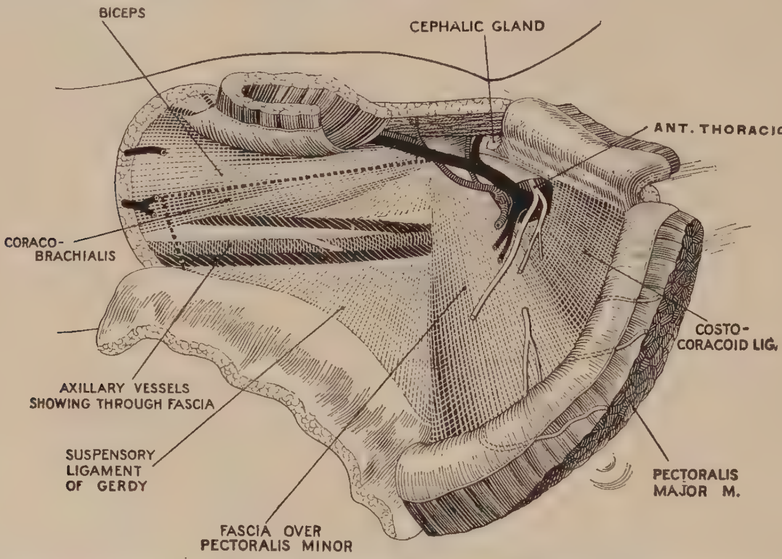

BICEPS
CEPHALIC GLAND
ANT. THORACIC N.
CORACO-BRACHIALIS
COSTO-CORACOID LIG.
AXILLARY VESSELS SHOWING THROUGH FASCIA
SUSPENSORY LIGAMENT OF GERDY
PECTORALIS MAJOR M.
FASCIA OVER PECTORALIS MINOR

Fig. 29.—Clavicoraco-axillary Fascia Covering Axillary Vessels. Dotted line indicates the first incision made in the fascial dissection of the axilla.

The next step in the fascial dissection of the axilla is the separation of the axillary fascia from the brachial (Fig. 30). This allows the reflection inward of the anterior fascial wall of the axilla. Begin at the entrance of the vessels into the axilla, ligate, and cut all their branches entering the axilla or passing forward to the pectoralis. Do not yet attempt to remove any fat, etc., from the axilla. Locate and trace the long subscapular nerve to the latissimus dorsi. Incise the fascia on the under surface of the latissimus dorsi,

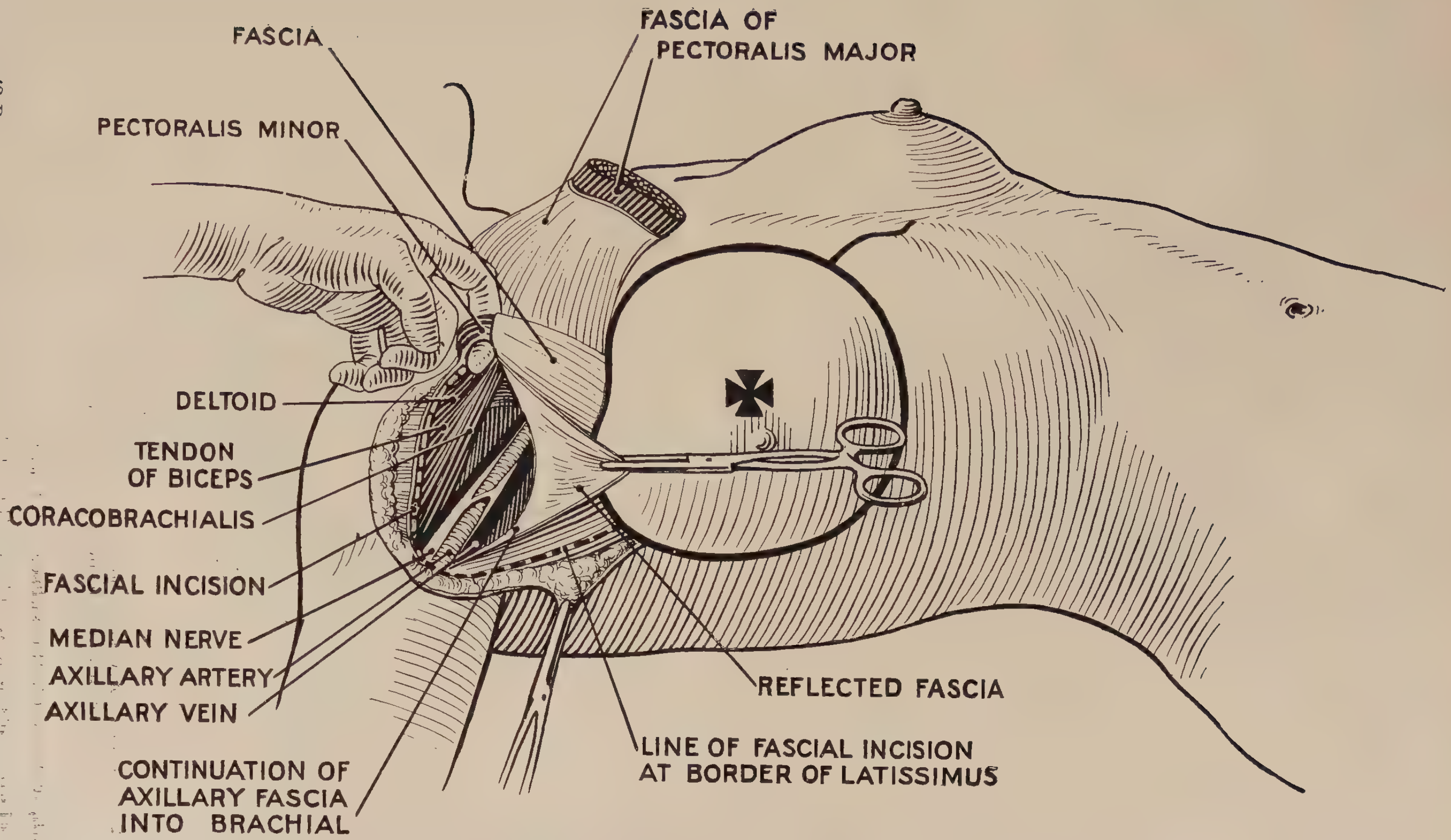

FASCIA
FASCIA OF PECTORALIS MAJOR
PECTORALIS MINOR
DELTOID
TENDON OF BICEPS
CORACOBRACHIALIS
FASCIAL INCISION
MEDIAN NERVE
AXILLARY ARTERY
AXILLARY VEIN
CONTINUATION OF AXILLARY FASCIA INTO BRACHIAL
REFLECTED FASCIA
LINE OF FASCIAL INCISION AT BORDER OF LATISSIMUS

Fig. 30.—Operation for Breast Cancer. The Insertion of Pectoralis Major has Been Cut and Muscle Turned Back on Chest Wall. The clavicoraco-axillary fascia has been divided over the coracobrachialis. The index finger is hooked under the insertion of the pectoralis minor.

free it to the anterior border, and then from the anterior face of the muscle up to the anterior border of the subscapularis. Free the subscapular fascia (Fig. 35) in one plane from the anterior to the posterior border of the scapula and pass the edge under the long subscapular nerve. The long thoracic nerve lies on the fascia covering the serratus magnus and will be readily found in the angle between the subscapular and serratus fascia (Fig. 36). Incise the subscapular fascia and retract the nerve from the chest wall. Putting the 2

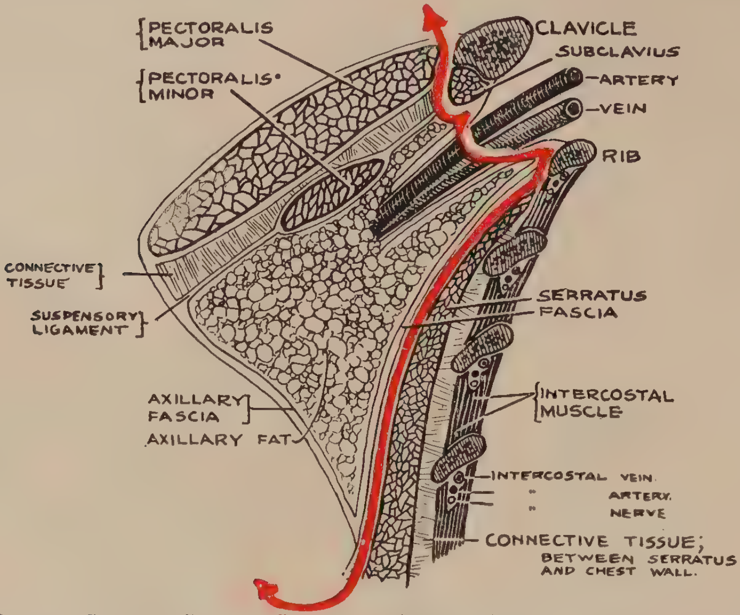

PECTORALIS MAJOR
PECTORALIS MINOR
CLAVICLE
SUBCLAVIUS
ARTERY
VEIN
RIB
CONNECTIVE TISSUE
SUSPENSORY LIGAMENT
SERRATUS
FASCIA
AXILLARY FASCIA
AXILLARY FAT
INTERCOSTAL MUSCLE
INTERCOSTAL VEIN.
" ARTERY.
" NERVE
CONNECTIVE TISSUE; BETWEEN SERRATUS AND CHEST WALL.

FIG. 31.—DIAGRAM SHOWING CORONAL SECTION OF AXILLA. Red line indicates the direction to be followed in the extrafascial dissection of the axilla.

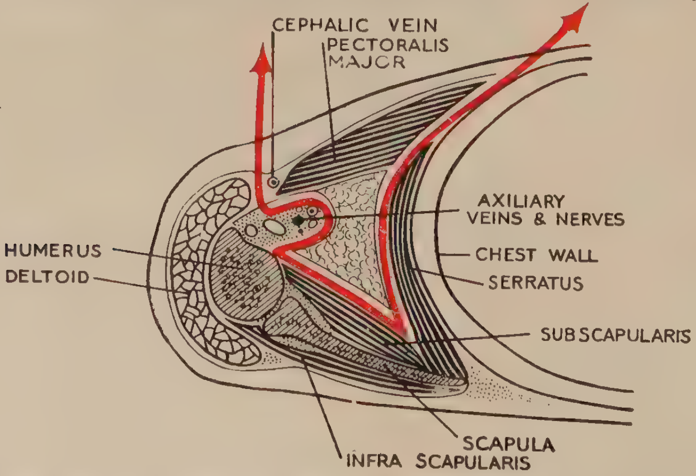

CEPHALIC VEIN
PECTORALIS MAJOR
AXILIARY VEINS & NERVES
HUMERUS
DELTOID
CHEST WALL
SERRATUS
SUBSCAPULARIS
SCAPULA
INFRA SCAPULARIS

FIG. 32.—DIAGRAM SHOWING HORIZONTAL SECTION THROUGH AXILLA. The red line indicates the direction to be followed in the extrafascial dissection of the axilla.

layers of fascia on the stretch (Fig. 36), pass a scissors underneath the nerve to the highest posterior point in the axilla, where the fasciæ from the subscapularis and the chest wall meet. This is about 1 to 1½ in. above and posterior to the vessels. Divide the fascia and reflect it up to the chest wall. It

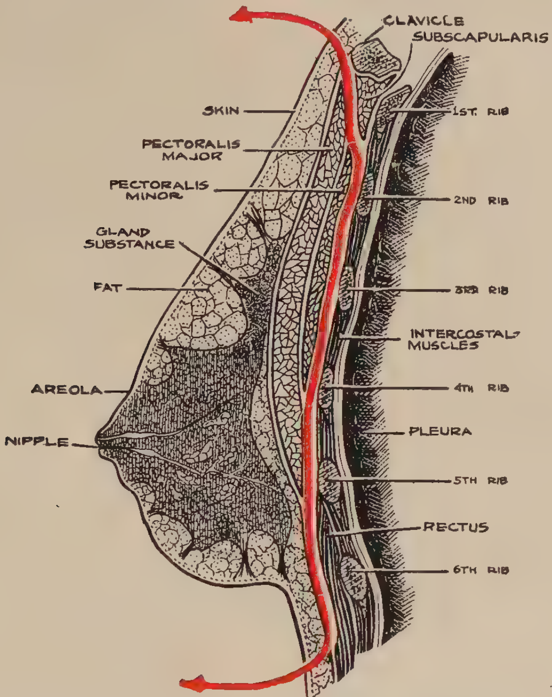

CLAVICLE
SUBSCAPULARIS
SKIN
1ST. RIB
PECTORALIS MAJOR
PECTORALIS MINOR
2ND RIB
GLAND SUBSTANCE
FAT
3RD RIB
INTERCOSTAL MUSCLES
AREOLA
4TH RIB
NIPPLE
PLEURA
5TH RIB
RECTUS
6TH RIB

FIG. 33.—DIAGRAM SHOWING SAGITTAL SECTION OF BREAST AND CHEST WALL. The red line indicates the direction to be followed in the extrafascial removal of the breast.

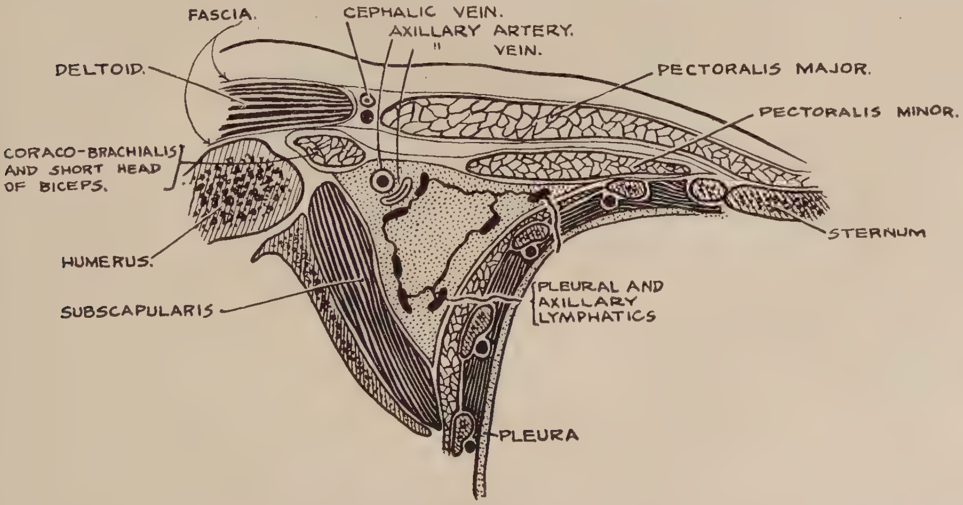

FASCIA.
CEPHALIC VEIN.
AXILLARY ARTERY.
" VEIN.
DELTOID.
PECTORALIS MAJOR.
PECTORALIS MINOR.
CORACO-BRACHIALIS AND SHORT HEAD OF BICEPS.
STERNUM
HUMERUS.
SUBSCAPULARIS
PLEURAL AND AXILLARY LYMPHATICS
PLEURA

FIG. 34.—DIAGRAM SHOWING CORONAL SECTION OF THE AXILLA WITH THE CONNECTIONS BETWEEN THE PLEURAL AND AXILLARY LYMPHATICS.

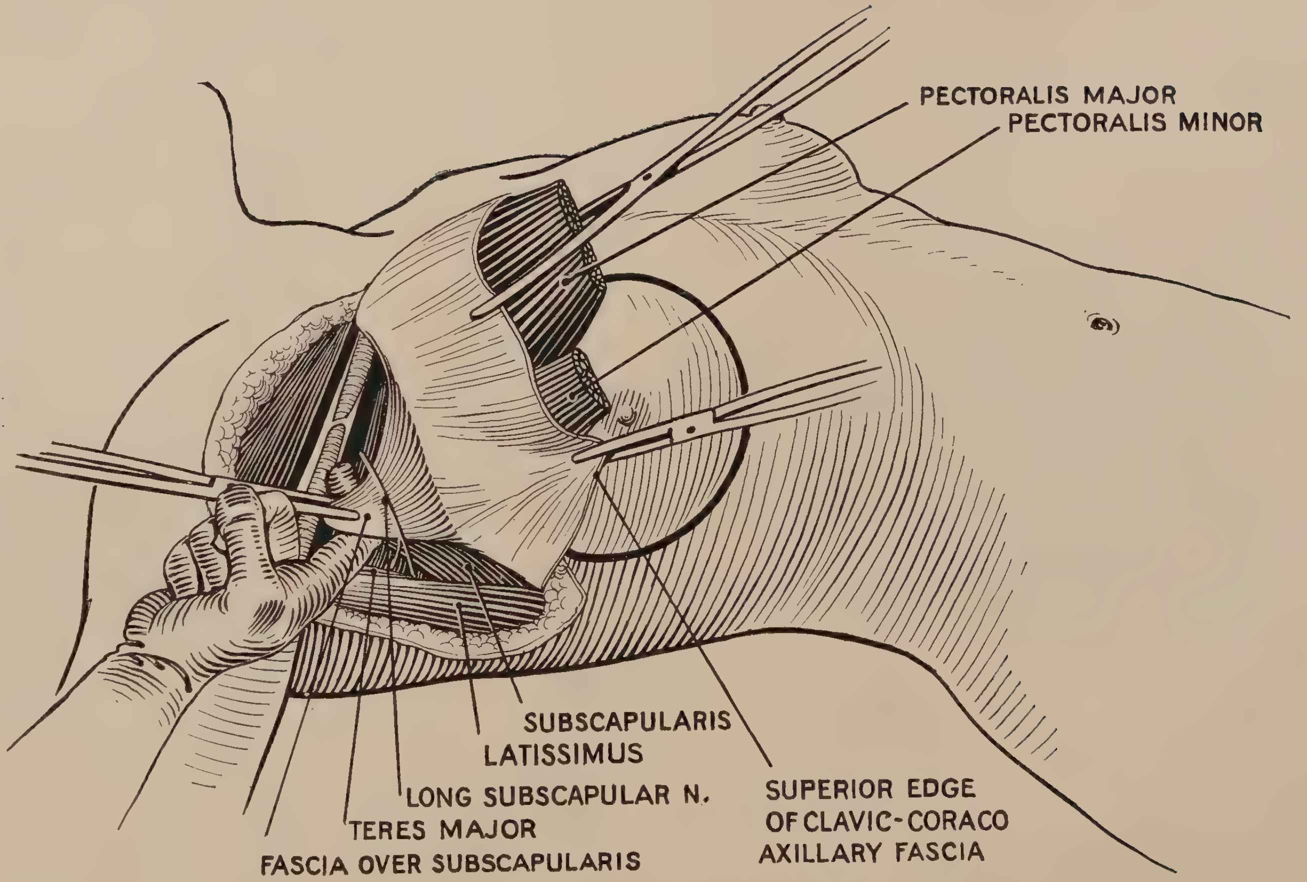

PECTORALIS MAJOR
PECTORALIS MINOR
SUBSCAPULARIS
LATISSIMUS
LONG SUBSCAPULAR N.
TERES MAJOR
FASCIA OVER SUBSCAPULARIS
SUPERIOR EDGE OF CLAVIC-CORACO AXILLARY FASCIA

FIG. 35.—THE CLAVICORACO-AXILLARY FASCIA HAS BEEN FREED AND RETRACTED INWARD. The finger is freeing the subscapular fascia.

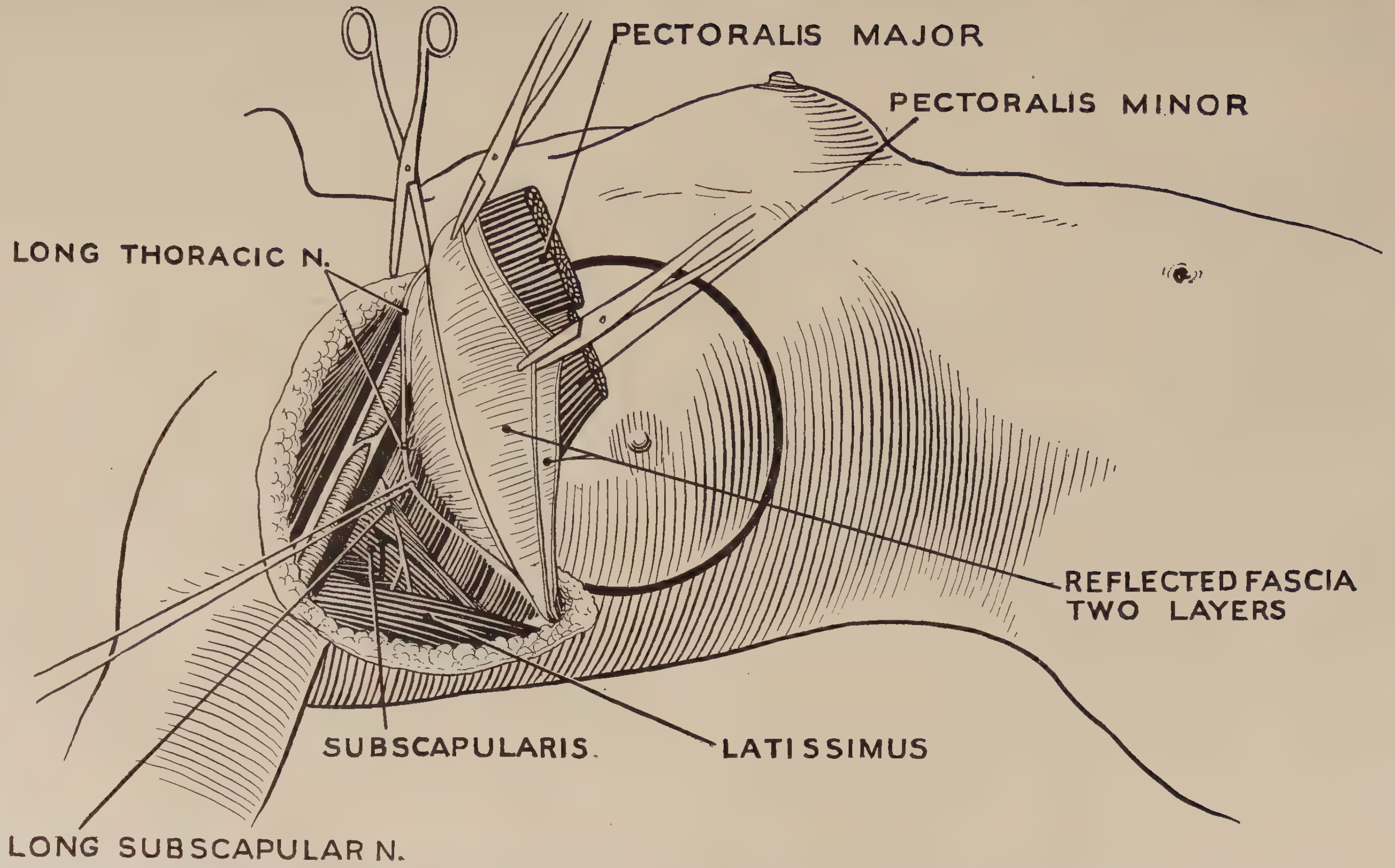

PECTORALIS MAJOR
PECTORALIS MINOR
LONG THORACIC N.
REFLECTED FASCIA TWO LAYERS
SUBSCAPULARIS.
LATISSIMUS
LONG SUBSCAPULAR N.

Fig. 36.—Operation for Breast Cancer. Clavicoraco-axillary fascia, subscapular fascia, and fascia over latissimus dorsi have been freed intact and retracted inward. The long thoracic nerve lies in the interval between the subscapular and serratus fascia.

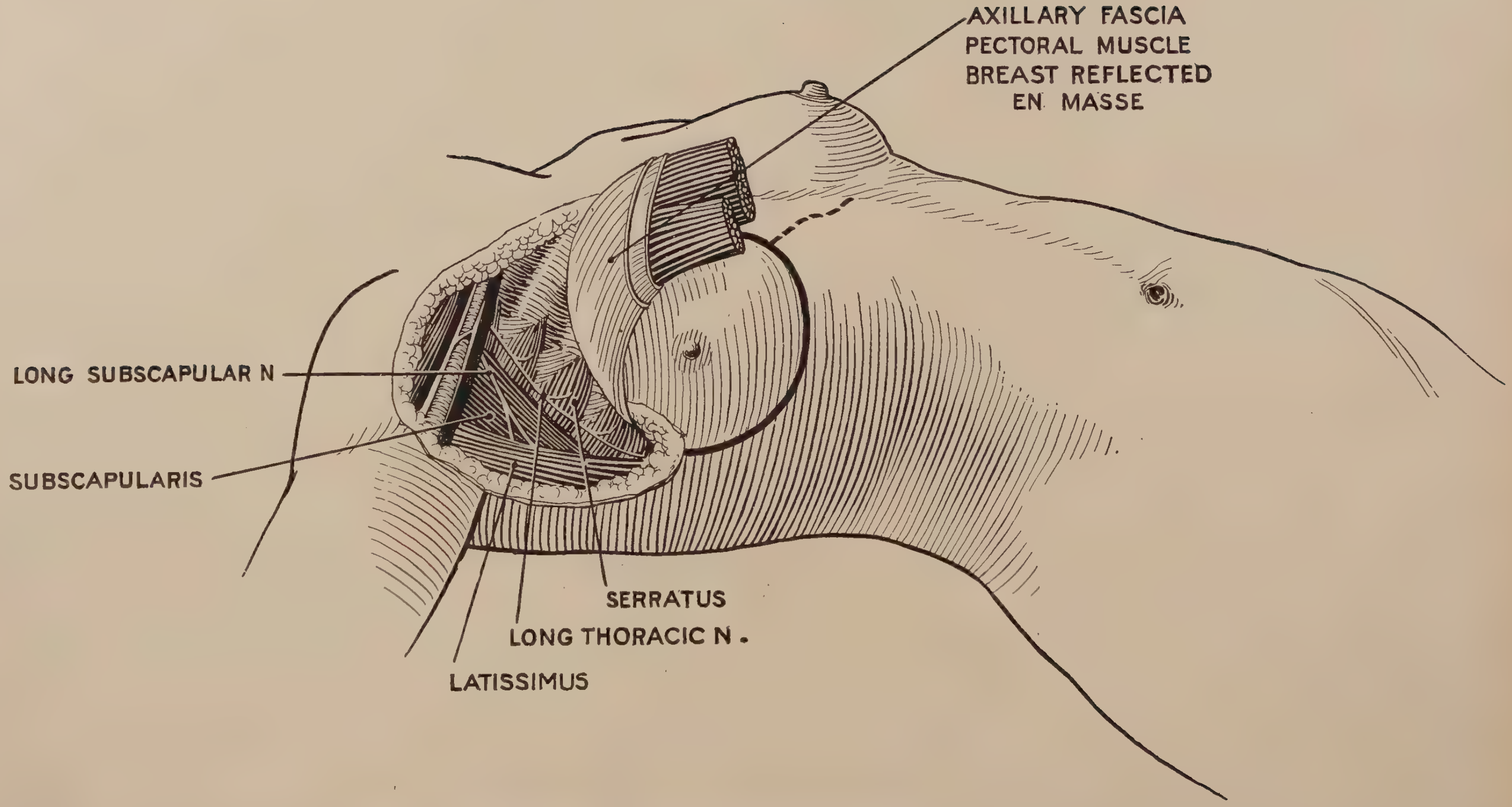

AXILLARY FASCIA
PECTORAL MUSCLE
BREAST REFLECTED
EN MASSE
LONG SUBSCAPULAR N
SUBSCAPULARIS
SERRATUS
LONG THORACIC N.
LATISSIMUS

FIG. 37.—OPERATION FOR BREAST CANCER. Long thoracic nerve has been freed, fascial dissection of the axilla completed, axillary fascia and its contents retracted inward and the removal of the pectorals begun.

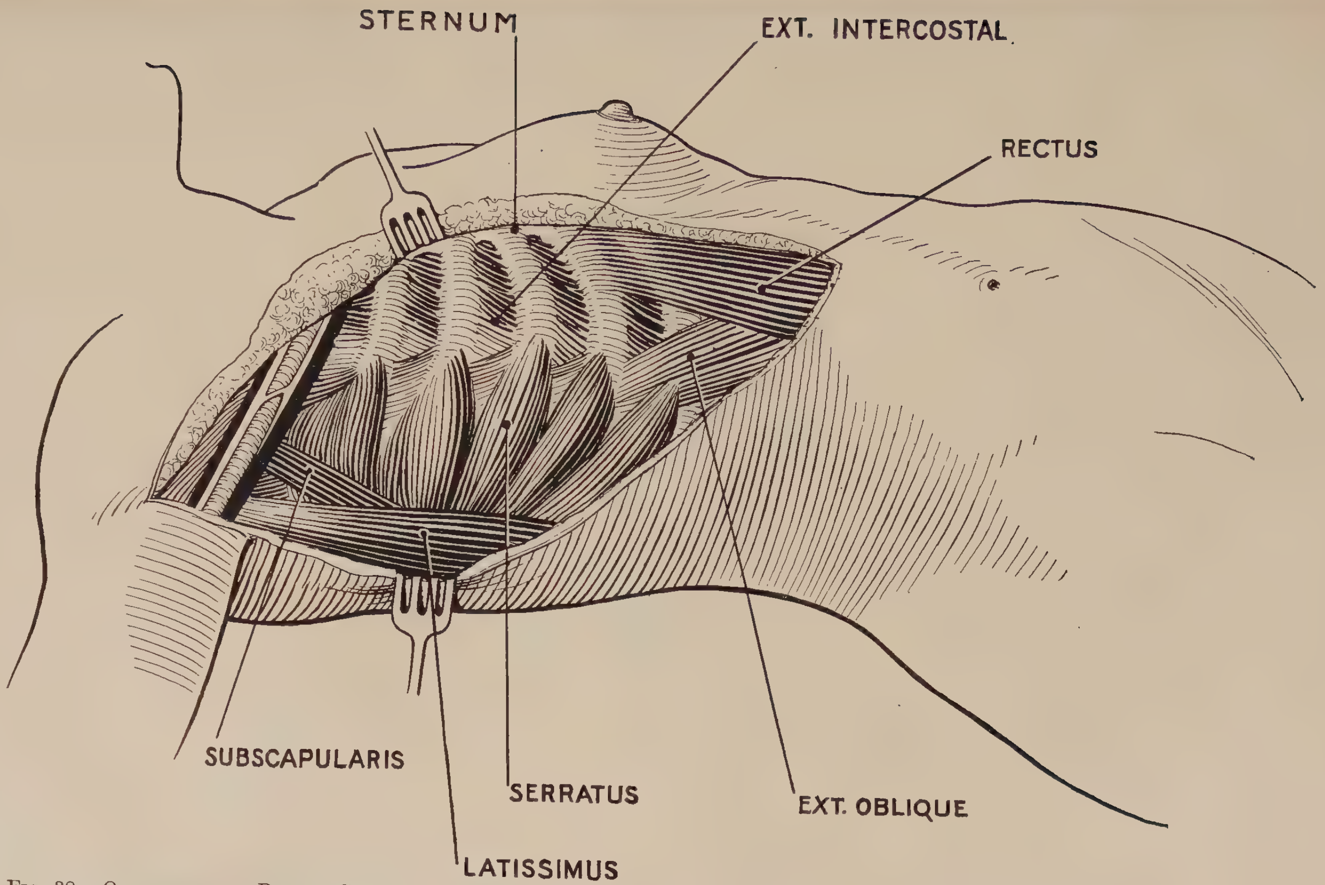

STERNUM
EXT. INTERCOSTAL.
RECTUS
SUBSCAPULARIS
SERRATUS
EXT. OBLIQUE
LATISSIMUS

Fig. 38.—Operation for Breast Cancer. Appearance of Wound Before Closure. Axilla has been swept clean of glands, fascia and fat; only bare muscles, long subscapular nerve and posterior thoracic nerve remaining. On the chest wall the fascia over the serratus magnus, and over the upper digitations of the external oblique, the pectoral fascia, a portion of the fascia on the opposite of the sternum and the upper portion of the anterior sheath of the rectus have been removed.

will be found that the fascia over the serratus magnus can be separated quite readily with the finger. In this way, the axillary fascia with its contents of fat, glands, vessels, etc., is kept intact, the separation having been done outside the axillary fascial lining. If the extrafascial removal of the axillary contents be correctly carried out, the axilla will be stripped absolutely clean, nothing remaining behind but the bare muscle, the long subscapularis, and the long thoracic nerves.

At this stage of the operation the cleft between the teres minor and the infraspinatus should be carefully searched for, as in a small percentage of cases one of the subscapular glands sometimes projects backward, lying without the axilla, and is liable to escape detection. Locate the cephalic gland over the cephalic vein. If present, remove it. Explore the supraclavicular region for enlarged glands. If these are present, undermine the skin over the clavicle, retract it apart, and clear out the glands, fat, and fascia. If this does not yield a sufficient exposure, add a vertical incision. Place a hot towel in the axilla and proceed to the third step in the operation.

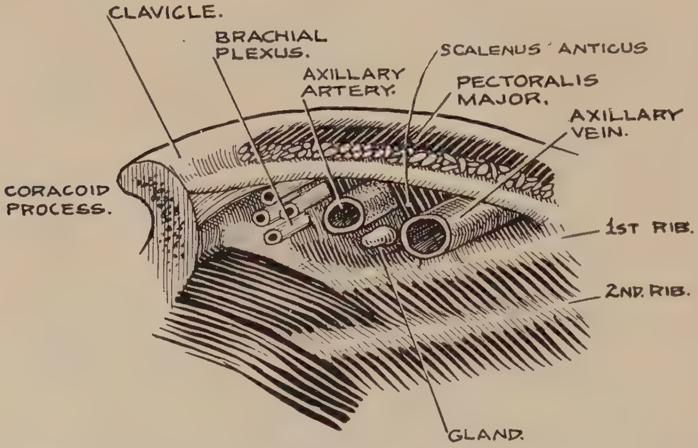


Fig. 39.—Summit of the Axilla with a Lymphatic Gland Lying on the First Rib Between the Artery and Vein.

III. The Removal of the Deep Fascia, Muscles, Fat, and Breast (Figs. 27, 37, 38).—The area of the deep fascia to be removed must be at least double that of the skin; a circle of skin with a diameter of 5 to 6 in. calls for the removal of a circle of deep fascia with a diameter of 10 to 12 in. The skin incision CDEFG is made just deep enough to open up the subcutaneous fat and does not extend down to the deep fascia. The flaps CDEF and CGEF are dissected back to the requisite distance, and the deep fascial circle outlined. The circle of deep fascia is now dissected from the subjacent muscle and reflected toward the center. Internally it begins on the opposite side of the sternum and is reflected externally to the margin of the pectoralis major. Inferiorly the upper portion of the anterior sheath of the rectus is carefully removed along with the digitations of the external oblique, arising from the fifth and sixth ribs. The upper and outer fascial margins of the circle have been freed in the axillary dissection. The pectoral muscles are now lifted from the chest wall, their fibers put on a stretch, the muscles severed close to their insertions, and the perforating intercostal vessels seized and ligated. Retract the intact mass inward and downward and remove the fascia and the digitations of the serratus that are in contact with the deep surface of the breast. The parts removed represent a convex lens (Fig. 22).

"The parts removed form a single biconcave lens with thin extensive edges" attached to the upper and outer quadrant are the axillary fascia and its contents.

IV. THE REVIEW (Fig. 38). **The subclavius should be in clear view, not obscured with fat.** Search the apex of the axilla where the vein emerges from the chest wall, and be sure that there are no glands or fat underneath the vein or between the vein and the artery (Fig. 39). Scrutinize the sulcus between the teres minor and infraspinatus for a possible extra-axillary subscapular gland. Search for the cephalic gland (deltopectoral gland).

V. CLOSURE.—A trial is now made to see the best method of closure. As a rule, the redundant flap ABCG (Fig. 27) is pulled downward and inward, and the axillary flap upward and inward as is shown in Figure 40. This method yields a sinuous scar which avoids the anterior axillary margin and provides a good covering for the axillary vessels and nerves. At other times a triradiate closure is made. If an extensive fascial dissection has been carried out, it is surprising to see how easily the large wound can be covered. The necessary dissection for a wide removal of the deep fascia so mobilizes the skin that it comes together without tension. If sufficient mobilization of the skin has not been obtained, a further degree can be derived

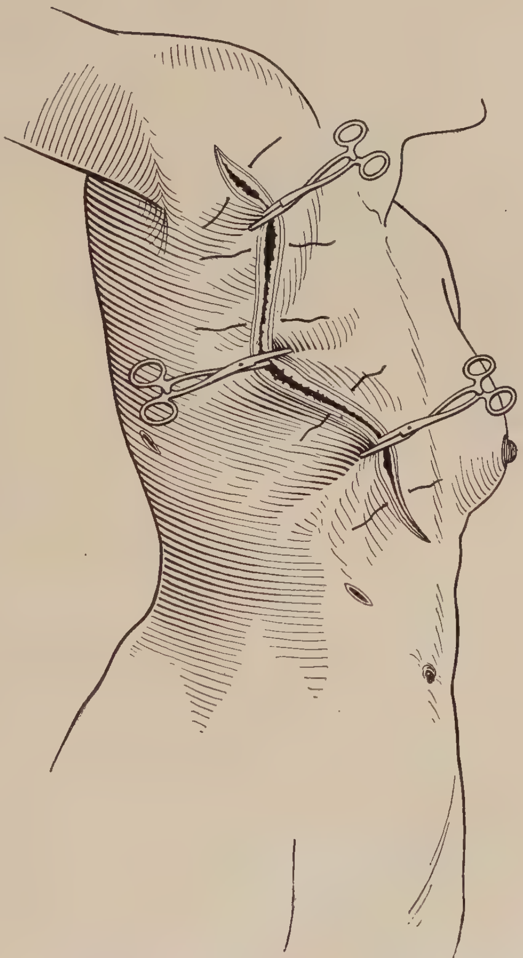


FIG. 40.—OPERATION FOR BREAST CANCER. Closure of incision.

by drawing on the natural skin reserves of the neck and the abdomen. Carl Beck first called attention to the value of the skin reserve beneath the breast and designed his operation with this in view (Fig. 26). Morestin, in his tegumentary mobilization, by wide undermining, amplifies Beck's principle and draws upon the skin reserves of the neck, as well as of the abdomen, thus greatly increasing the usefulness of the procedure. We have frequently employed this method and found it invaluable.

According to the extent of the wound, make 1 or 2 stab punctures and insert split rubber tube drains: one at the posterior border of the latissimus dorsi for the axillary space, and another at the lowest level of the undermined area (Fig. 41). Close the wound with interrupted silkworm-gut sutures and adjust the intervening skin edges with fine silk sutures. If the vitality of the skin is impaired by the tension, score it with the knife. Tuck the skin well up into the axilla and hold it in this position by a soft pad. If the clavicular fibers of the pectoralis major have been removed, a soft pad should be placed just below the clavicle to obliterate a potential serum-collecting space, by forcing the skin against the chest and clavicle. Use a generous dressing and secure with a bandage or a breast binder. The arm is kept by the side, the forearm flexed across the chest and supported by a sling. Return the patient to bed and keep in a semi-sitting posture with the knees flexed. This relieves the tension on the flaps, provides good drainage, and helps to prevent lung complications.

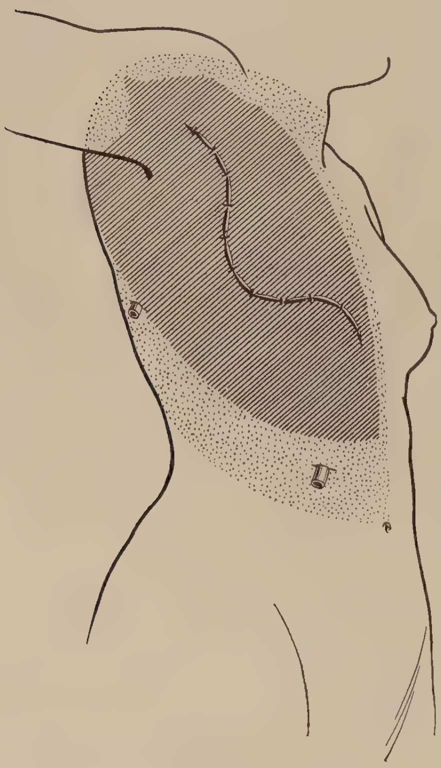


Fig. 41.—Completed Operation for Breast Cancer. Shaded area shows the extent of deep fascia removed; dotted area the undermining necessary for the mobilization of the skin. Note that undermining extends upward on the neck and downward to the abdomen.

The position of the arm by the side, with the forearm supported across the chest, is superior to the abduction of the arm. The side position relieves tension on the flaps; obliterates the dead spaces, where serum might collect; lessens the possibilities of scar-tissue formation between the under surface of the skin and the chest wall, and yields a mobile scar. After an extended trial of the abducted and semi-abducted arm position, we are convinced that the anatomical and functional results obtained by this method are inferior to those in which the arm is kept by the side. We believe with Morestin that healthy tissue does not retract.

If the sound tissues can be brought together so closely that scar tissue cannot form, the wound will heal with but little retraction and such a skin will stretch readily of itself or can be made to stretch by appropriate exercises.

COMMENT.—During the operation the skin edges should be protected from unnecessary trauma and wrapped in hot towels to preserve their nutrition and prevent the possibility of future ulceration. If the skin wound cannot be completely closed, the raw area is to be covered with Thiersch skin-grafts; such a condition rarely arises, however, where an extensive removal of the deep fascia has been performed. Plastic flaps from the back are employed to cover large skin areas. Since Verneuil, in 1858, devised his autoplastic operation, numerous methods of swinging over the sound breast to cover the defect have been proposed. *The best of these procedures is Payr's* (Fig. 42). This is an improvement on the so-called cyclops operation, where the transplanted breast was placed over the middle of the sternum.

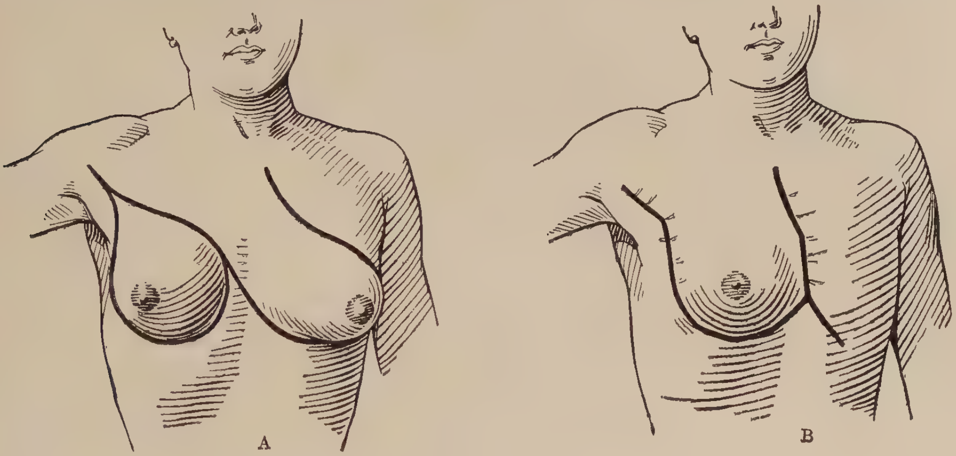


FIG. 42.—AUTOPLASTIC OPERATION. Payr's method.

The amount of deep fascia to be removed varies with the position of the growth. If the growth is in the sternal margin, one-half of the deep fascia beneath the opposite breast is excised; if at the lower margin, the deep fascia to the umbilicus; if in the axillary tail, the fascia over the deltoid well back on the latissimus dorsi. If the tumor is in the periphery of the upper hemisphere, the supraclavicular fossa should always be explored. According to Rodman, Halsted and his pupils are removing the glands of the neck less frequently, while other American surgeons are operating on the neck in an increasing number of cases. The removal of the glands is indicated if there is a noticeable enlargement of the supraclavicular glands, an enlargement of the subclavian glands, or without an enlargement of the supraclavicular glands in all peripheral tumors of the upper hemisphere.

The partial removal and plastic repair of the pectoral muscles yield no improvement in the mobility of the arm and are unsound surgical procedures.

Restriction of the movements of the arm is not caused by the removal of the muscles, but by the limitation of the cicatrix. The worst results from the functional standpoint that we have yet seen have occurred in cases in which plastic partial resections of the muscles have been performed.

In addition to the operative treatment, Keating-Hart employs fulguration. The radical operation, with a macroscopical removal of the disease, is first performed and the whole raw operative area is then subjected to powerful sparking with the high-frequency current. In this way the microscopical disease is destroyed by cauterization and according to Keating-Hart the soil upon which the cancer cells thrive becomes altered to one that is antagonistic to their growth. The method is yet too new to pass judgment upon. In the late cases it seems to relieve pain, check hemorrhage, and stimulate the growth of granulations and epithelium. The original claim for this operation that it would prevent recurrences has not been substantiated.

ACTUAL CAUTERY.—If the slightest suspicion is entertained about the thoroughness of the removal, the actual cautery should be lightly passed over the doubtful area. The cautery destroys the neglected cancer cells, sears up the open-mouthed blood-vessels and lymphatics, thus reducing the risks of future dissemination.

After-treatment.—The immediate general treatment is that of any operation of similar magnitude. The patients after 3 to 4 days are often more comfortable in a reclining chair than in bed. Elderly people, patients with bronchitis, emphysema, etc., should be encouraged to sit up as soon as possible. The dressing is to be changed at the end of 24, 48, or 72 hours, and the drainage tubes removed or shortened according to circumstances. Owing to the division of the main lymphatics at the apex of the axilla, the escape of lymph may take place for several days. If it becomes excessive, place a pad over the infraclavicular region and in the apex of the axilla. This complication follows more frequently if the arm is held in the abducted position, less frequently if the skin is well tucked up in the axilla and the arm kept by the side. The tension sutures under favorable conditions are removed the fifth or sixth day, the remaining sutures on the seventh or eighth day. Primary union will be obtained in from 7 to 10 days. Delays may be encountered by collections of serum under the flaps, by necrosis and by ulceration of the skin edges. Such dry, tough, necrotic skin sloughs slowly; if the resulting granulating area warrants it, skin-grafting should be employed, thereby shortening the time of wound healing. We emphasize the importance of early systematic exercises in the obtaining of good functional results. The following plan adopted from Leaf's "Cancer of the Breast" (24) has been used, and found most admirable:

> "In order to prevent stiffness of the arm and shoulder, gentle movements should be commenced at an early date. Flexion and extension of the fingers and wrist may be commenced on the third or fourth day, and of the elbow on about the sixth or seventh day. If there is no undue tension on the wound, the arm may be gently raised

from the side of the chest once or twice a day at the end of the first week. When the incisions have soundly healed, the patient should do the following exercises for ten minutes daily: Both arms should be stretched out at right angles to the body with the palms directed downward and should then, by a series of oscillatory movements, be raised to a higher level. These movements should, if possible, be carried out before a mirror in order that the patient can be certain that her back is kept straight and that both arms are at the same level. In addition to removing stiffness, this exercise helps to develop the deltoid muscle which always becomes more or less flabby after the operation.

"Another exercise which is extremely useful consists in facing a wall or door and moving both hands up as high as possible, making a mark each day to show the level to which the hand on the affected side has been raised. In these exercises both hands and arms should always be used, for the muscles of the affected side are encouraged to work more efficiently if the corresponding muscles of the healthy side are put into action at the same time. The rapidity with which free mobility returns after operation naturally varies very much. Nearly all my patients have been able to raise the hand to the back of the head some two months after operation. In many of the cases where movement is limited, this is not brought about by the scar tissue formed after the operation, but is the result of stiffness in the shoulder joint; hence, the importance of early movements unless there is some special reason to the contrary."

The pain and tenderness in the scar and its surroundings vary greatly. Of necessity there will be areas of anesthesia, and with the return of sensation there will be various manifestations such as prickling, shooting pains, etc. To prevent unnecessary alarm, all these possibilities are to be explained to the patient. The scar remains tender for some time and should be protected by a pad of well-powdered soft linen. Excellent light-weight models of the breast are now made in silk buckram.

PROPHYLACTIC TREATMENT OF OPERATED AREA BY X-RAY EXPOSURE COMBINED WITH THE ADMINISTRATION OF THYROID EXTRACT.—Three to 4 weeks after the operation a short course of bi-weekly X-ray exposures is begun and continued for a period of 3 weeks, the rays being applied from as many directions as possible, the exposed skin always being protected by the necessary filters. On the theory that X-rays diminish the activity of the thyroid gland, small doses of thyroid extract are administered. As a routine, we subject our operative cases to X-ray treatment on the ground that in recurrences radiotherapy has accomplished more than any other known method, and every precaution should be taken to prevent the possibility of local recurrences. Radium seems to possess no advantages over the X-ray. As supplementary measures in the treatment, good food, fresh air, sunlight, and suitable tonics are to be employed. The use of the sera of Hodenpyl, Doyen, etc., is not to be advised.

Dangers and Complications.—MORTALITY.—Considering the size of the wound and the severity of the operation, the mortality rate is surprisingly low. According to Rodman, in 2,133 operations collected from the practice of 21 American surgeons between 1893 and 1903, the death-rate was less than

1 per cent. In 960 cases reported before the American Surgical Association in 1907 the operative mortality was 2.07 per cent. These operations were all radical operations and in a fair proportion a neck dissection had been carried out. In 708 cases operated on in the Mayo Clinic from January 1, 1890, to November 1, 1911, there were 3 deaths, .42 per cent. The reported causes of death in the above lists have been shock, hemorrhage, bronchitis, pneumonia, and pulmonary embolism.

COMPLICATIONS.—The following postoperative complications may occur: Persistent neuralgia due to the overstretching of the nerve trunks, to the operative trauma, to the imprisonment of nerves in scar tissue, or to recurrences along the courses of nerves or in the spinal cord. Damage to the axillary vessels requiring ligation or suture has occurred. Resection of a portion of the vein has been required for adherent glands. Varying degrees of edema of the arm are encountered during different periods of convalescence, transitory edema occurring in about 15 to 20 per cent. of the cases, permanent edema in from 5 to 10 per cent. The swelling in the arm may be due to a recurrent growth pressing upon or obstructing the lymphatic channels; it may be purely mechanical, arising from operative interference with the venous or lymphatic circulation; or it may be due to the pressure of an axillary scar. If due to injury of the venous return flow, a "brawny arm" may develop. In the lymphatic variety the edema reaches its maximum in from 4 to 6 weeks and then gradually declines until the arm almost reaches the normal, or it may persist in a mild degree. This simple variety should be watched for and treated. Exercise, hard work, etc., are prohibited. The return lymph circulation should be aided by the application of an "Ideal" bandage; during the day the arm is supported in a sling, at night on pillows. Gentle massage, hot-air douching and static electricity are valuable aids in treating this condition. In the severe forms of edema Handley's lymphangioplasty may be applied.

Handley's lymphangioplasty consists in the insertion in the subcutaneous tissue of strands of silk that are to form a system of capillary drains for the lymph (see Lymphatics).

RESTRICTIONS OF MOVEMENTS OF THE ARM.—Restrictions of movements of the arm may be due to formation of joint and muscular adhesions, limitation of the cicatrix, or damage to the nerve trunks. The first can be prevented by the proper after-treatment, the second by correct planning of the incision. The scar should avoid the anterior border of the axilla (Handley's operation), or if it extends to the arm, this portion should run in the long axis of the arm (Jackson's operation), or the incision should not encroach on the arm but should be confined to the chest (Rodman's operation). The aim in closing the wound should be to produce a sinuous or a triradiate scar in order to break the force and avoid the direct pull that occurs in a straight cicatrix. Restricting cicatrices are to be mobilized by systematic exercises and massage. In the severe cases an operative revision of the scar will be necessary. Damage to the nerve trunks is to be subjected to suitable electric treatment.

Results of the Radical Operation.—We believe with Rodman that "surgery should cure one-half of all cases provided that they can be subjected to the complete operation early in the course of the disease." A satisfactory study of the operative cures is rendered extremely difficult by the diversity of conditions and associated circumstances under which the radical operation is performed. The accuracy of the reported results must of necessity be problematic, as there is no other criterion of an absolute cure than a thorough post-mortem examination, which is rare, while a complete post-mortem examination, with a minute examination of the osseous system, is still more rare. Cases not operated on live from 20 to 28 months, the extremes being 2 months and 20 years. As a convenient standard Volkmann's 3-year limit of freedom from recurrences is used. The fallacy of this arbitrary standard can be seen when we consider that Ransohoff reported 37 cases with recurrences appearing 7 years or more after the first operation, and one 20 years and 11 months after. The supposed general cures measured by the 3-year standard will be obtained in from 40 to 57 per cent. of the cases. Of this number 17 per cent. to 20 per cent. will later succumb to local or general metastases.

Local cures measured by the same 3-year limit will show from 50 to 60 per cent. cures. In the complete operation local recurrences occur in 6 to 20 per cent. of the cases and the majority of them appear within 6 months, about 5 per cent. after the third year.

General metastases occur in from 15 to 20 per cent. of all cases; in from 4 to 6 per cent. of the cases they occur early without local recurrences. The following conditions influence the prognosis of the individual case:

1. The age of the patient. The older the patient, provided she stands the shock of the operation, the better will be the end result from the standpoint of a cure.

2. The duration of the growth. The prognosis is good in early stages of carcinoma of the breast and bad when axillary involvement is present (66⅔ per cent. of the former are cured; 66⅔ per cent. of the latter die).

3. The malignancy of the tumor. The best results are obtained in colloid, 66 to 80 per cent. cures; adenocarcinoma, 50 to 75 per cent.; Paget's disease, 12.5 to 20 per cent.; scirrhus, 23 to 40 per cent.; and lastly, in medullary carcinoma, 16 to 48 per cent. As a general rule, the cancers showing the least anaplasia give the best results.

4. Adherence to the skin renders the prognosis unfavorable. Halsted reports in 110 cases with axillary involvement and negative neck 24.5 per cent. of cures, 70 per cent. of cases without demonstrable glandular involvement as cured, and 80 per cent. free from recurrences at the end of 3 years.

Treatment of Local Recurrences.—The only contra-indications for operations on recurrences are those which would bar the primary radical operation. Enough cases are now on record to show not only that life may be prolonged by operating on recurrences, but that apparent permanent cures have been obtained. Greig reports a case which had been operated on 6 times during a period of 30 years. In the cases of nodular recurrences in the skin, where the deep fascia and all other lymphatic paths have been excised, we can look on the recurrence as a collection of isolated cancer cells that have been left behind in the original operation. A wide excision should be immediately made with the actual cautery or with the knife and the actual cautery, or fulguration applied. If the recurrences are numerous, subject the patient to an energetic course of X-ray or radium treatment. Recurrences among the scapular muscles arise in the lymph glands and vessels which accompany the subscapular and circumflex vessels. Such recurrences are hard to deal with and may necessitate an interscapulothoracic amputation. Recurrence in the opposite breast or axilla should be treated by a radical operation. The clinical outlook for prolongation of life in these cases is far more hopeful than would be expected. In three such cases, one patient lived 3 years, one 3½ years, and the other was still living 7 years after the second operation.

TREATMENT OF INOPERABLE CARCINOMA

The treatment is both general and local.

The General Treatment.—The fallacies in the therapeutics of cancer have been well put by Handley:

> "The progress of a cancer is normally accompanied by retrogressive or curative processes. It is not surprising, therefore, that occasionally visible nodules or even the primary growth may undergo complete fibrosis. In such cases of partial cure the appearance of fresh metastases elsewhere soon shatters the false hopes which have been raised. A happy ignorance of this aspect of the natural history of carcinoma has not infrequently enabled the discoverer of a medicinal cure for cancer to maintain a sincere faith in his remedy for some considerable time. The natural regressive processes which in untreated cases usually pass unobserved are ascribed to the action of the remedy."

Sufficient time has now elapsed to show the worthlessness of Doyen's, Hodenpyl's, and other allied sera, and the uselessness of the injection of selenium, colloid copper, trypsin, etc.

Oöphorectomy.—Beatson of Glasgow (4) advocated oöphorectomy as a treatment for inoperable carcinoma, basing it on the fact that a double oöphorectomy, by causing a hastening of the menopause, would consequently bring about an atrophy of the breast. Many cases have been reported as improved, and a few cures are claimed. We have had the opportunity to observe the results in a small number of cases, and in 2 cases a temporary benefit was noted. The best results are claimed in patients under 50 years of age.

Local Treatment.—The local treatment consists in palliative operations, the use of radium, X-rays, fulguration, and local applications; in sarcomata the use of Coley's toxins.

PALLIATIVE OPERATIONS.—In our experience the palliative operations have given distressing results and we restrict them to those cases in which the presence of a foul-smelling painful ulcer is a source of mental and physical suffering. **The radical amputation is the best palliative operation.** The intense pain caused by the cancerous involvement of the brachial plexus may require an interscapulothoracic amputation and a division of the posterior nerve roots. With the same object in view, the posterior roots of the sacral nerves have been divided to relieve the pain caused by recurrences involving the great sciatic. Division of the anterolateral columns of the spinal cord has been advised and practiced for persistent pain in the lower extremities by Spiller and Martin.

Carcinomatous hydrothorax is to be treated by repeated aspirations; *hydroperitoneum* by repeated tappings. Patients who have developed hydrothorax live but a short time. On the other hand, those with hydroperitoneum live longer. The clinical conditions known as "brawny arm" may become so aggravated that an interscapulothoracic operation will have to be performed.

TREATMENT BY RADIUM AND X-RAY.—For the technical application and a fuller discussion the reader is referred to Chapter XVIII, Volume I. In a certain number of inoperable cases treated with X-ray the pain is relieved and there is an apparent decrease in the size of the tumor, with a general improvement in the patient's condition. In other cases the growth is markedly stimulated and the disease runs a rapid course. In a third class of cases the patients seem to suffer from marked toxic absorption symptoms caused by a breaking down of the tissues. The same phenomena have been noticed in the use of radium. Overdosage with this agent may cause marked local destruction of the tissue with intense toxic absorption symptoms and death.

LOCAL APPLICATIONS.—Of the local applications for ulcerating carcinomata we have had the best results from acetone and formalin.

ACETONE.—Acetone is a powerful, penetrating, dehydrating agent causing the tissues to dry up, thus checking bacterial activity. On the unprotected skin it is extremely painful, but, if properly confined to the ulcerated area, only slight pain is experienced. Scrape away as much of the ulcerating surface as possible, smear the surrounding skin surface with a thick coat of vaselin, confine the acetone solution to the ulcerated surface, and leave it in contact for 15 minutes. Remove the excess and pack the wound with gauze wrung out in acetone. This dressing is left in place for 24 hours. The acetone is applied every 5 to 7 days, according to the reaction and the condition of the wound.

FORMALIN.—The use of formalin (liquor formaldehyd) has been advocated by Stewart, of Minneapolis. A 40 per cent. solution of formaldehyd is freely applied to the ulcerated surface and left in contact for 1 minute. It is then neutralized by an abundant solution of hydrogen peroxid. In ulcerating carcinoma it checks discharge, odor, and causes little or no pain. It is especially valuable in fungating sarcoma.

FULGURATION (KEATING-HART).—See page 668.

Inoperable *sarcoma* should be treated with Coley's mixed toxins. In sarcomata both the radium and the X-ray give better results than they do in carcinoma.

TREATMENT OF SPONTANEOUS FRACTURES

These are caused by the replacement of the bony tissue by new growths. Any of the long bones with the exception of those below the knee and elbow may be involved. The fracture may be the first symptom to call attention to the presence of a bony metastasis. Complaints of rheumatism, pains in the bones, etc., in patients with carcinoma of the breast, especially those with cutaneous nodules, call for careful X-ray study of the bones. The most common sites of fracture are the upper end of the femur and the middle of the humerus. The pain resulting from spontaneous fractures is not often severe. Bony union being possible, the fracture should be treated according to general surgical principles.

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THE SURGICAL TREATMENT OF DISEASES OF THE SPINAL CORD AND MENINGES

CHAPTER XIV

THE SURGICAL TREATMENT OF DISEASES OF THE SPINAL CORD AND MENINGES

CHARLES A. ELSBERG

LUMBAR PUNCTURE

Puncture of the spinal canal for diagnostic and therapeutic purposes is founded upon the researches of Quincke (1872), of Corning, and of August Bier. The operation is based upon the physiological fact that cerebrospinal fluid circulates in the entire subarachnoid space of the brain and spinal cord, and upon the anatomical facts (1) that the lower end of the spinal cord extends only to the first or second lumbar vertebra, while the spinal canal with its meningeal lining extends down to the sacrococcygeal openings; and (2) that the bony wall of the spinal canal is not a complete one, so that spaces remain between the arches of the vertebræ through which a needle can be passed into the spinal canal and subarachnoid space.

Lumbar puncture is done either for diagnostic or for therapeutic purposes. In the first case, the object is to obtain cerebrospinal fluid for examination, for the presence or absence of normal and abnormal constituents (Wassermann test, increase of cells and globulins, presence or absence of bacteria, presence of blood in fractures of the skull or spine, of pus cells in meningitis and brain abscess, etc.). The determination of the pressure of the cerebrospinal fluid in the canal is also of diagnostic importance.

The normal pressure, according to Sahli, is between 5 and 7.3 mm. of mercury or 60 to 100 mm. of water. Pathologically the pressure of the cerebrospinal fluid is raised in a large number of diseases, such as intracranial tumors, abscesses, hemorrhage, meningitis of all kinds, etc. It may reach very high figures—300, 500, or even 1,000 mm. of water—the highest pressures being found in serous meningitis and in brain tumors.

The Therapeutic Value of Lumbar Puncture.—The withdrawal of cerebrospinal fluid is of value in some cases of posterior basic meningitis in children, but it is of greater value in tuberculous meningitis. In this latter disease the fatal outcome is usually hastened through the ventricular distention, and if the deleterious effects of this distention are overcome by repeated lumbar puncture, the patient's life may be saved. Undoubted cases of cure of tuberculous meningitis by repeated and long-continued punctures are on record (Freyhan, Neisser).

Lumbar puncture is sometimes useful in mild chronic hydrocephalus in childhood, but better results can be obtained in this condition by means of puncture of the corpus callosum (q. v.). It is also an aid in the treatment of increase of intracranial pressure due to expanding lesions of the brain, such as brain tumor and abscess, excepting where the disease is located in the posterior cranial fossa. Lumbar puncture is also used for the injection of drugs into the spinal canal, Flexner serum in epidemic cerebrospinal meningitis, magnesium sulphate (Meltzer) and antitoxin in tetanus, cocain, tropacocain, stovain, etc., for spinal anesthesia.

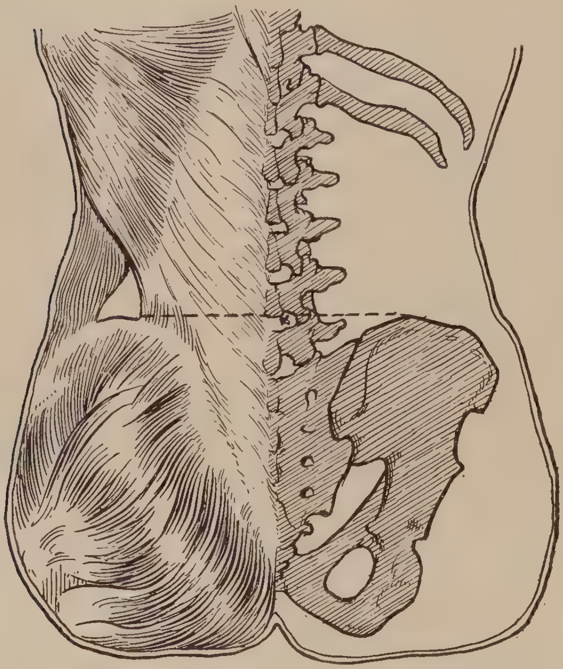

Fig. 1.—Anatomy of Spinal Puncture. (From Kocher's Chirurgische Operationslehre, 5th Edition, p. 61.)

Site of Puncture.—The spaces between the third and fourth and fourth and fifth lumbar laminæ are especially large, and the puncture is usually done through one of these spaces, although in some instances a higher level has to be selected. A line which connects the highest level of the iliac crests will generally cross the fourth lumbar vertebra, and the favorite site for the introduction of the needle is just above this level (Fig. 1). The spaces between the laminæ are largest when the spine is flexed, i. e. when the body is bent forward. According to Quincke, the distance from the skin to the subarachnoid space in the lumbar region is usually 4 to 6 cm., but in fat or muscular individuals it may be anywhere from 7 to 10 cm., and the needle will have to be inserted to that depth before spinal fluid is obtained.

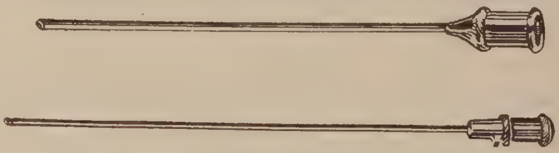

Fig. 2.—Needle for Lumbar Puncture.

Instruments.—Various needles are used for spinal puncture, but I prefer one marked off in centimeters, whose point is not an acute angle, and which contains a well-fitting stilet (Fig. 2). The needle should fit a syringe by a sliding, not a screw, joint, and the syringe should have an asbestos packing, so that it can be boiled.

Technic.—The technic of spinal puncture is simple. The patient is placed on his side near the edge of the bed or operating table with the body bent forward and the thighs and legs flexed, or he may be seated on the edge of the bed or table with the body bent forward. The skin is sterilized (washing with alcohol and painting with tincture of iodin), and the fourth lumbar spine located on a level with the highest parts of the iliac crests. Either in the median line or just to one side of the spinous process of the third or fourth lumbar vertebra, the needle armed with the stilet is made to puncture the skin. Pointing either in the median line or toward it, and in a slightly upward direction, the needle is rapidly pushed forward to the required depth (Figs. 3 and 4). The operator will feel the resistance of the fasciæ and muscles and, if a bony obstruction is encountered, the direction of the needle will have to be altered a little. When the spinal canal has been entered, the stilet is withdrawn; the fluid will escape either drop by drop or in a stream. It is rare that no fluid can be obtained; this usually means that the subarachnoid space has not been reached and that the needle must be pushed still farther. If blood is obtained, it means that the needle has injured the extradural venous plexuses; the needle should be withdrawn, washed out with sterile water, and re-inserted. The color of the fluid and the pressure with which it escapes should be noted. Normal fluid is clear as water and escapes drop by drop or in a slow stream. Various methods have been devised to measure the pressure of the fluid, but up to the present time the practical value of such measurements has been small. The pressure of the cerebrospinal fluid is measured by means of a manometer which is attached to the needle by a side arm. Various needles for this purpose have been described, but a simple apparatus such as that of Quincke will give

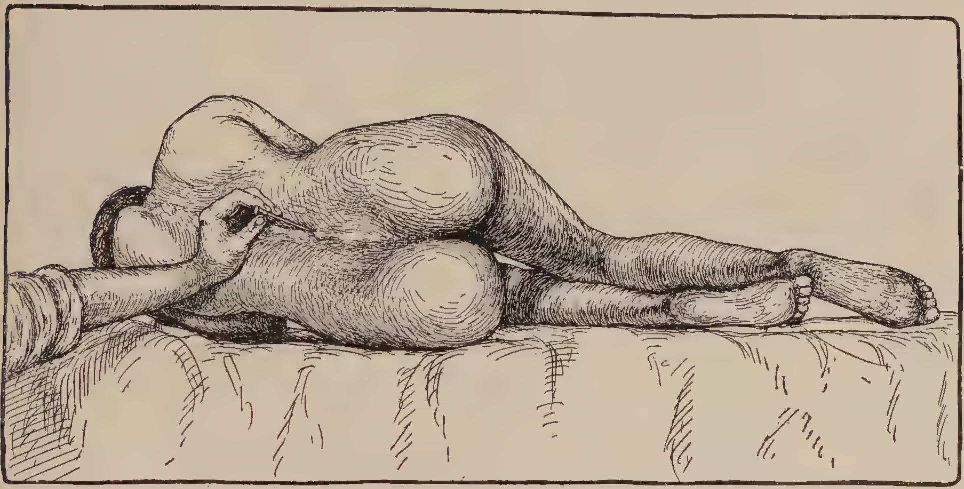

Fig. 3.—Introduction of Needle for Lumbar Puncture with Patient Recumbent.

perfectly satisfactory results (Fig. 5). Its construction will be understood from the accompanying illustration. The pressure of the fluid is read off on a scale which is held by the side of the glass manometer tube. When the fluid is to be allowed to escape, the tube is turned down so that the fluid can run out. For examination, 5 to 10 c. c. of the fluid should be allowed to run into a sterile test tube. If the fluid is of a brown or yellow color, a suspicion of old bleeding or of a spinal neoplasm is justifiable.

When fluid is to be removed for the relief of internal hydrocephalus, no more than 20 to 50 c. c. should be allowed to escape at one time. A similar amount should be withdrawn every few days. During operations upon the brain, when there is very great intracranial tension, the withdrawal of fluid by lumbar puncture is often of value.

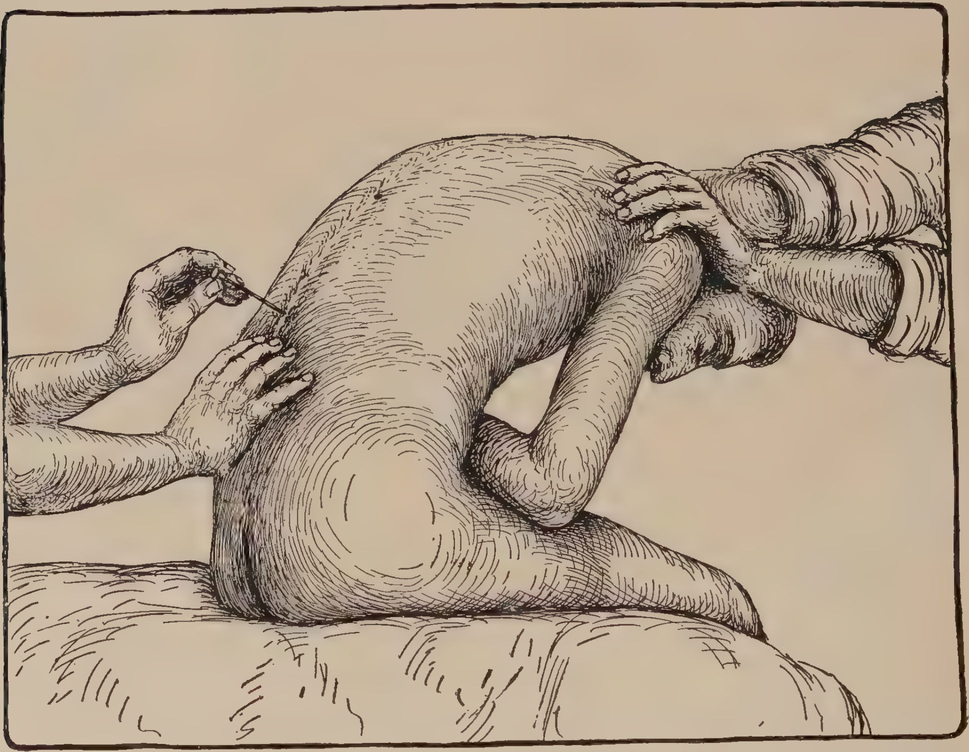

Fig. 4.—Introduction of Needle for Lumbar Puncture, with Patient in Sitting Position.

Injection of Drugs.—When a drug is to be injected into the spinal canal, as much cerebrospinal fluid should be allowed to escape as the amount of solution that is to be injected. The amount of serum or antitoxin that is injected in various diseases will, of course, depend upon the strength of the solution used and the age of the patient. For spinal anesthesia the substance used is generally to be obtained commercially in prepared ampules, often combined with adrenalin. Cocain, tropacocain (Giesel), novocain (Einhorn), and stovain (Fourneau) have all been used with success, but tropacocain and stovain are recommended by Bier. The dose of tropacocain is about 5 cg., and that of stovain 5 to 6 cg. for an adult. Ampules which contain 2 c. c. of a 5 per cent. sterile solution are on the market. The details of spinal anesthesia are considered in another volume.

After-effects.—Lumbar puncture is a slight operation, without danger if perfect asepsis be observed. After the withdrawal of even small quantities of cerebrospinal fluid, the patients often suffer for a day or a number of days from headache, dizziness when they sit up, nausea, and vomiting. Occasionally there may be syncope.

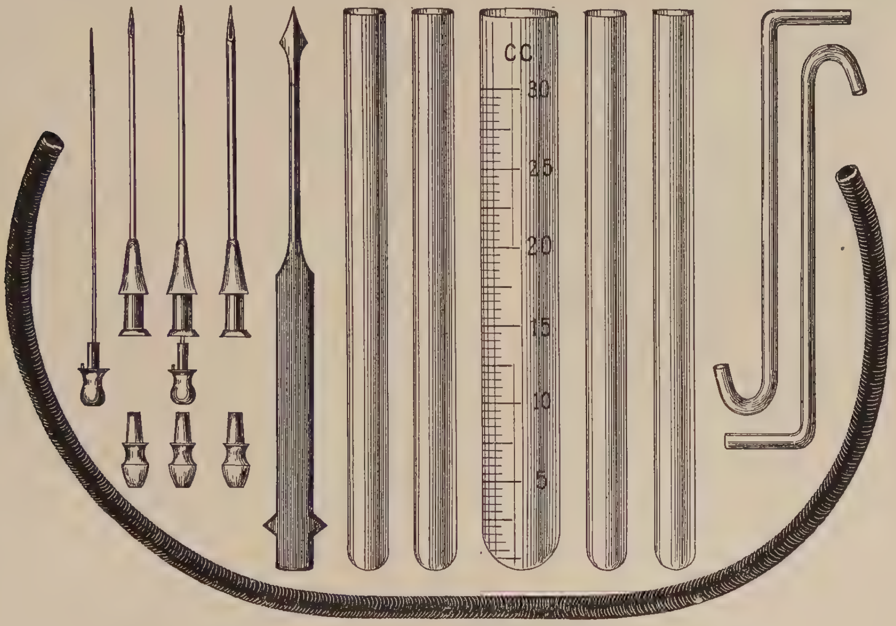

Fig. 5.—Quincke Needle and Set for Lumbar Puncture.

The headache usually appears a few hours after the lumbar puncture has been done, and occurs frequently even when there is no disease of the nervous system and although little fluid has been removed. It will not infrequently persist for a number of days. It is advisable to keep the patients in bed for 24 hours after the spinal puncture, as the headache and other symptoms will disappear much more quickly when the patient remains in the recumbent position.

The symptoms are apt to be especially severe in patients with an intracranial neoplasm, and sudden death has occurred in a number of instances within a few hours of the lumbar puncture. We should remove as little fluid as possible in these patients. Lumbar puncture should never be done when there are symptoms of an expanding lesion in the posterior cranial fossa for fear of sudden medullary death. Allard has collected 23 cases of death within 24 hours in cases where there was an obstruction of the iter or the foramen of Magendie.

I have seen the symptoms of a spinal tumor much exaggerated within a few hours after a spinal puncture in a patient who before had presented only slight signs of cord involvement, and soon after developed a complete motor and sensory paraplegia. In this patient only 5 c. c. of fluid had been removed.

LAMINECTOMY

In most cases in which the spinal canal has to be opened the exposure should be a liberal one. Therefore, the operation must consist of a wide removal of the posterior arches of several vertebræ. As we shall see later, the functions of the vertebral column are almost fully recovered after the complete removal of the spinous processes and laminæ of a number of vertebræ. According to my experience, the operation of hemilaminectomy, as described by A. S. Taylor, has only a very limited field of usefulness, because this operation does not give as good an exposure as the complete operation. Osteoplastic operations, as described by Marion, Cavicchia, Bickham, Urban, and others, are more complicated and bloody than those in which the bone is removed; they are also more time-consuming, and do not give as free a field. In the following I shall describe the operation of complete laminectomy as I am accustomed to perform it.

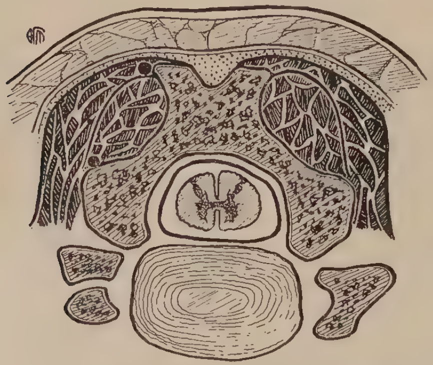

Fig. 6.—Cross-section of Back in Cervical Region, Showing Muscles and Spinal Canal. Black dots indicate location of main blood-vessels.

Anatomy.—The anatomy of the spinal column, of the spinal canal and its contents should be carefully studied by the surgeon who desires to do successful spinal surgery. The following are some of the most important features of the gross anatomy: The spinous processes are bifid in the cervical region, are usually fairly thin and well separated from each other, so that each spinous process can be removed with ease. In the dorsal region the spines point backward and downward and gradually increase in thickness; they overlap each other to a considerable extent in the upper 10 vertebræ. The lower 2 dorsal and the lumbar spines are very thick and short, more deeply placed between the thick paravertebral muscles, and point directly backward.

In the cervical and dorsal vertebræ (excepting the eleventh and twelfth dorsal) the laminæ overlap each other from above downward, so that, when the laminæ are removed with rongeur forceps, it is always more easy to work upward than downward.

The muscles are thickest in the lower dorsal and lumbar regions, but are easily freed from the spines and laminæ. There are but few large blood-vessels in the muscles; the largest run in the intermuscular septa. The accompanying figures show the usual location of the largest vessels (Figs. 6, 7, and 8).

The ligamenta subflava are very thick in the lower dorsal and lumbar regions. Sometimes they are torn loose from their attachments by a slight traumatism, and then may compress the cord beneath.

In the cervical and upper dorsal regions the dura is often covered by a layer of adipose tissue several millimeters in thickness. This extradural fat layer has been mistaken for a tumor.

The dura mater which envelops the cord does not contain any blood-vessels of a size sufficient to give the operator any trouble, but between the anterior surface of the dural sac and the posterior surface of the bodies of the vertebræ lies a plexus of veins. Troublesome bleeding may occur when the attempt is made to separate the dural sac from the posterior surface of the body of a vertebra.

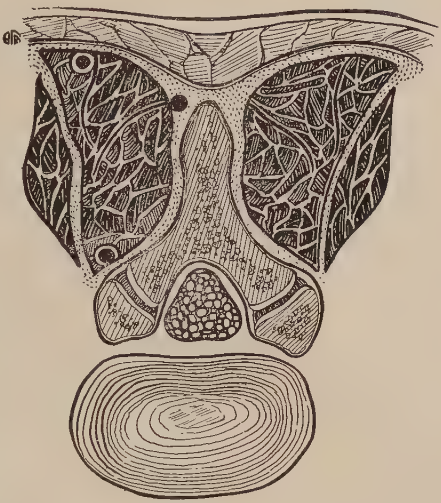

Fig. 7.—Cross-section of Back in Mid-dorsal Region.

The pia mater closely invests the cord, while the arachnoid is separated from the pia by the cerebrospinal fluid, so that one may with justice speak of the arachnoid "sac." This arachnoid sac lies against but is not normally adherent to the inner surface of the dura mater, and it is usually possible to incise the dura without injuring the arachnoid sac. Inside the arachnoid sac is seen the spinal cord.

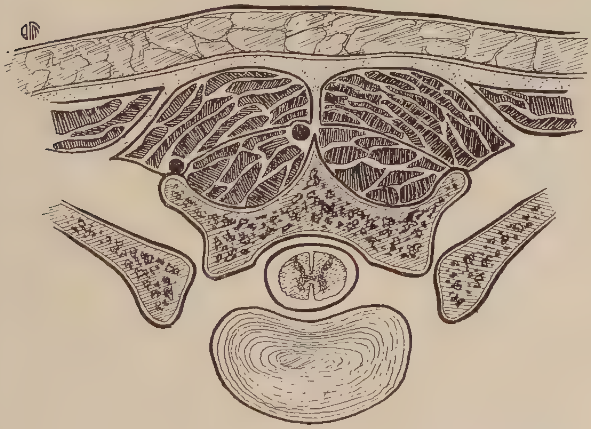

Fig. 8.—Cross-section of Back in Lumbar Region.

The cord is held in place in the spinal canal by the nerve roots and by the ligamentum denticulatum. The dentate ligament is a fibrous band of great importance for the surgery of the spinal cord. It is derived from and attached to the lateral aspect of the pia mater on the cord, midway between the anterior and posterior roots. On each side of the cord the ligament extends from the foramen magnum to the level of the first lumbar vertebra. From its origin from the cord each ligament extends outward and is attached to the inner surface of the dura by numerous dentations or slips (Fig. 9). It is due to this ligament that a tumor which grows on the anterolateral or posterolateral aspect of the cord will press upon only anterior or posterior roots for a long time. By means of the dentate ligament the cord may be rotated so that its anterior surface is exposed. For this purpose 1 or 2 slips of the ligament have to be divided.

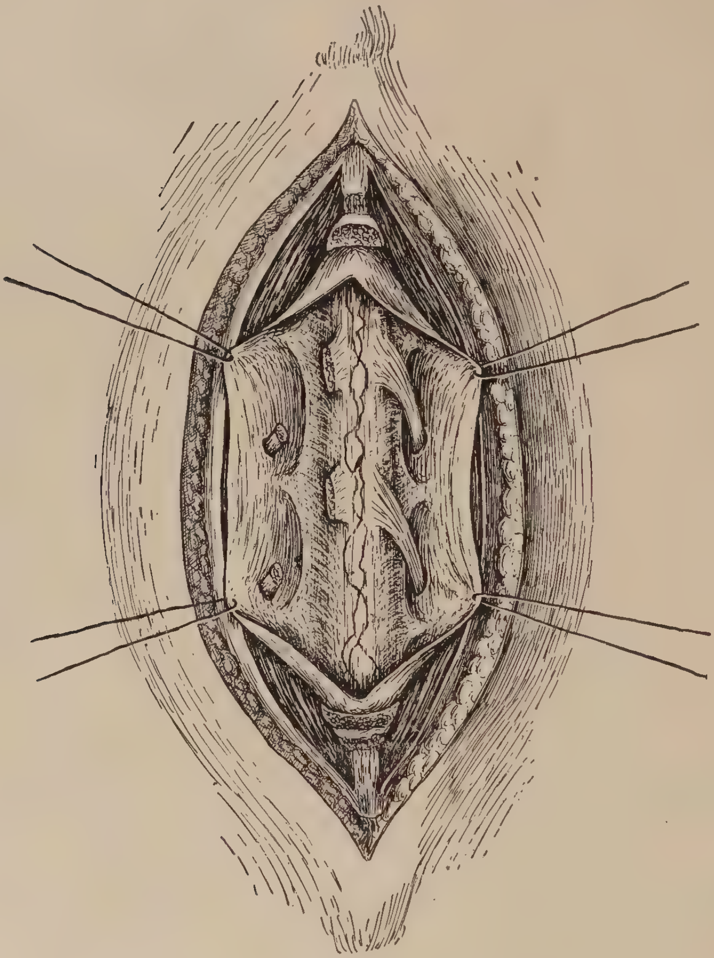

Fig. 9.—Spinal Cord Exposed to Show the Dentate Ligament. On the left side the posterior roots are divided to show the relations of the ligament.

The dentate ligament ends below, at the level of the first lumbar vertebra, in a fork-shaped extremity (Elsberg), upon which rests the first lumbar posterior root; the fork is therefore a landmark useful to identify the first lumbar posterior root (Fig. 10).

The spinal cord ends at the level of the lower border of the body of the first lumbar vertebra. The cord is much enlarged in the cervical and lumbar regions—the cervical and lumbar enlargements. In the removal of the laminæ in these regions special care must be taken that the cord is not pressed upon.

Position of the Patient; Anesthesia.—The part of the vertebral column to be operated upon should be as much ventrally flexed as possible, so as to separate the spinous processes and to bring them near to the surface of the skin.

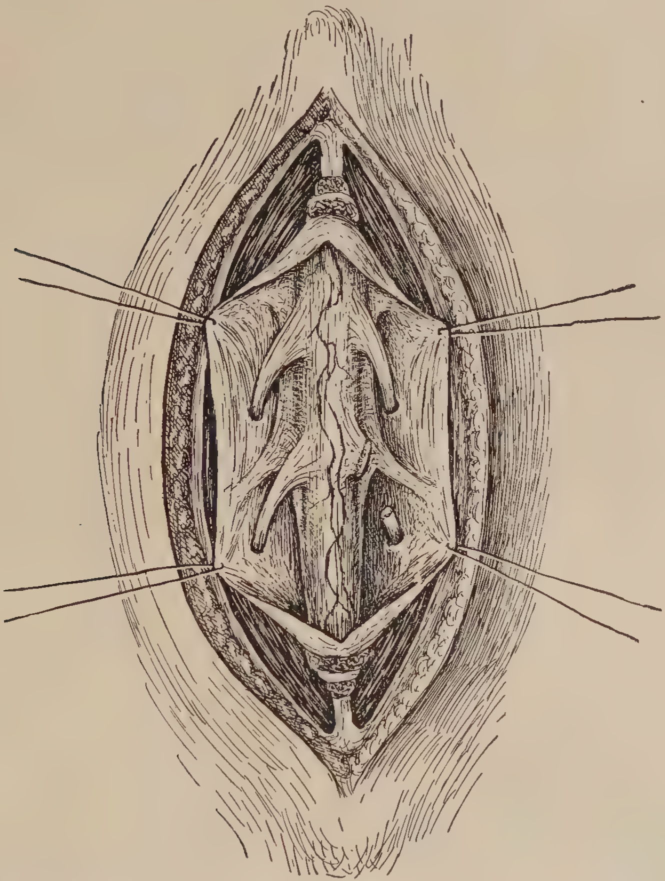

Fig. 10.—The Lower End or "Fork" of the Dentate Ligament.

When the laminectomy is to be done in the cervical region, the patient must be in the same position as in a suboccipital craniotomy (q. v.). The patient must be placed flat upon the abdomen with pillows under the shoulders so that the thorax is well away from the operating table and respiration is not interfered with. The head must rest upon an extension of the table or outrigger, so that the head can be flexed upon the chest (see Fig. 11). If the dorsal vertebræ are to be operated upon, the patient must be in the prone position, with the shoulders raised from the table by means of pillows, and a large bolster under the abdomen so that the dorsal column is ventrally flexed. A similar position is useful for a laminectomy in the lowest dorsal and lumbar regions. In many instances, however, the patient can be placed in a semiprone position, the abdomen and chest on one side being raised from the table by pillows.

The prone or almost prone position occupied by the patient upon whom a laminectomy is to be done is very apt to make the giving of the anesthesia difficult. In cervical laminectomy the anesthetist has often to sit underneath the operating table so as to be out of the way of the operator and his assistants. The anesthesia can usually be made more easy by the introduction of catheters into the nose, or still better by means of intratracheal insufflation anesthesia.

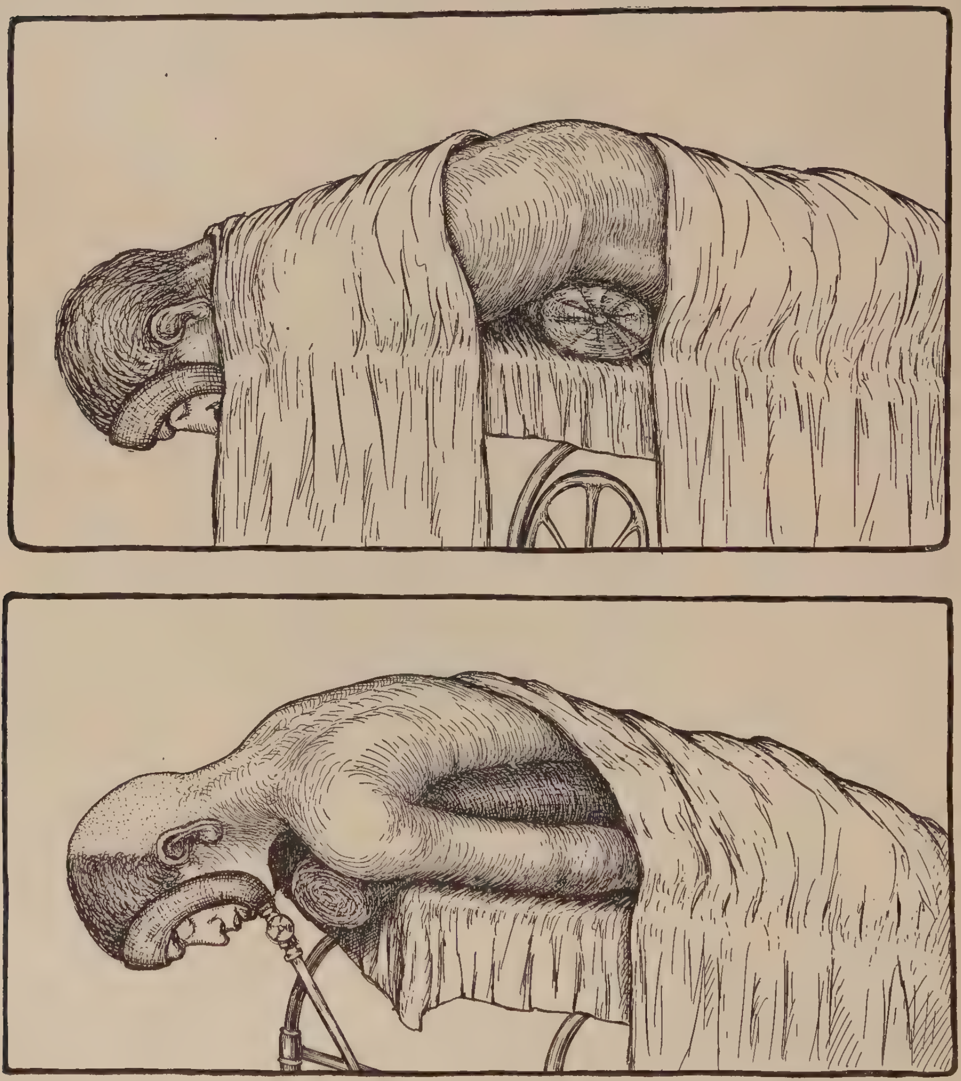

Fig. 11.—Positions of Patient for Laminectomy.

During the past year I have used intratracheal anesthesia with ether for many of my spinal operations and can recommend it very highly. The anesthetist must always see that **the chest wall is not against the operating table,** so that respiration is not interfered with. In operations in the cervical region he must also be **careful that the neck of the patient is not compressed by the edge of the table or the outrigger.** Ether is the anesthetic of choice for a spinal operation.

Technic of Operation.—Usually at least 3 vertebræ have to be exposed, and often 5, 6, or 7 laminæ have to be removed before the entire spinal lesion is exposed. It is always better to take away an arch too much than one too little.

The skin incision should be made in the median line, its center over the middle spinous process to be taken away. The spinous processes that are to be removed should always be determined by counting from below upward and from above downward. In this way we are sure that the proper spines have been marked out. The cutaneous incision should divide all tissue to the spines. Then with rapid cuts of the scalpel the fascia and muscles on one side of the spines and laminæ are separated from the bone, the separation being accomplished by the aid of a broad elevator (Fig. 12). After the spines and laminæ are well exposed, a gauze packing is inserted on the one side and the same procedure followed on the other side. The bleeding is seldom profuse, rarely requiring the use of artery forceps, and is usually entirely controlled by the packings. It is advisable to wait 1 or 2 minutes, then to remove the packings and to draw the wound edges apart by

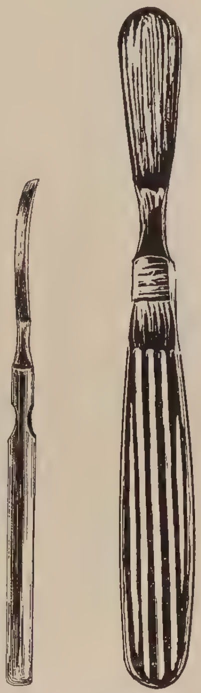

Fig. 12.—Periosteal Elevators for Laminectomy.

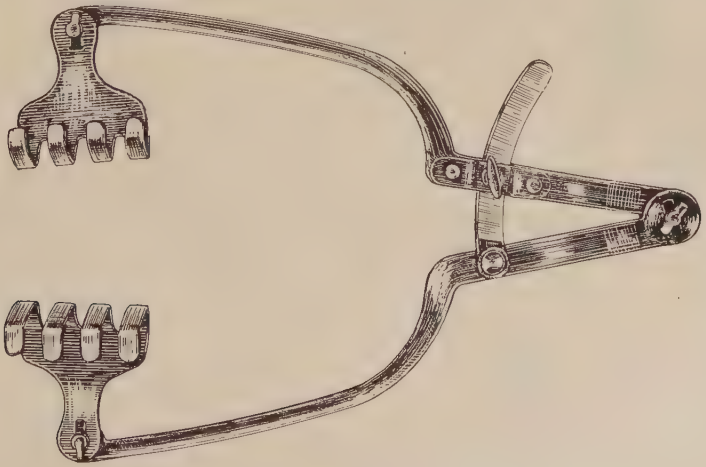

Fig. 13.—Automatic Retractor Used in the Operation of Laminectomy.

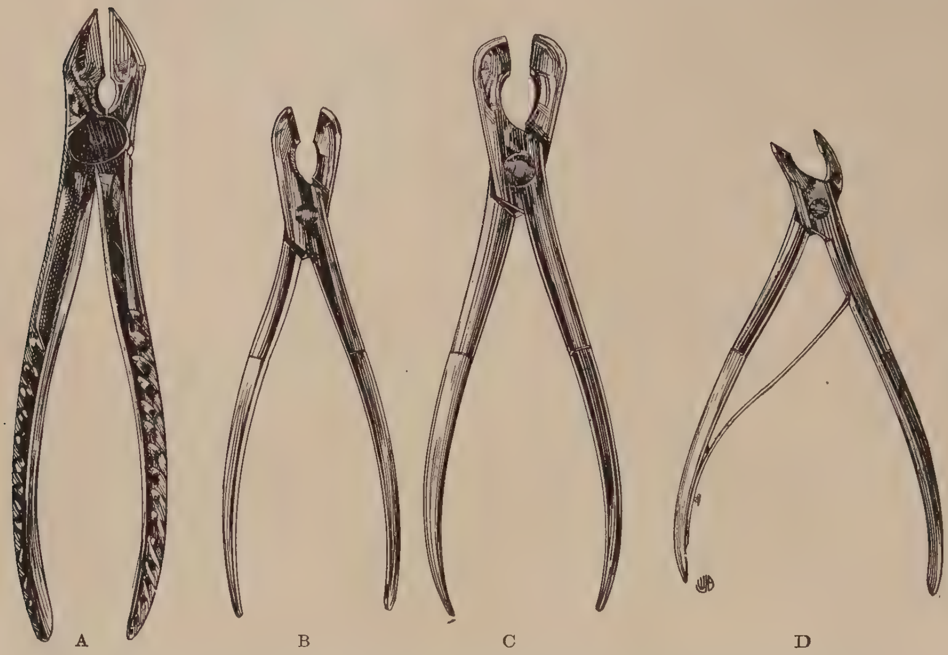

FIG. 14.—VARIOUS RONGEUR FORCEPS FOR SPINAL OPERATIONS. A, Horsley spine forceps; B, C, small and giant rongeur; D, rongeur useful for removing overhanging laminæ.

means of an automatic retractor (Fig. 13). The retractor not only controls all bleeding, but gives an excellent exposure of the field of operation and saves one assistant.

The interspinous ligaments are now divided by rapid cuts with the scalpel.

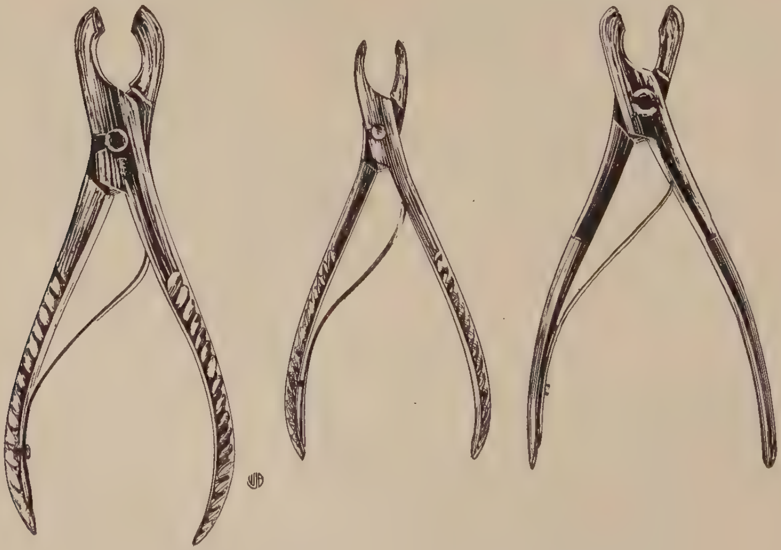

FIG. 15.—VARIOUS RONGEUR FORCEPS FOR SPINAL OPERATIONS.

With a large rongeur forceps (Fig. 14C) or with a Horsley spine forceps (Fig. 14A), the spinous processes are removed at their bases. Then with quick bites with smaller rongeurs, of which several sizes and types should be at hand (Figs. 14B, D and 15), the laminæ are removed well out to their articulating surfaces, beginning with the lowermost ones and working upward. During this procedure great care must be taken that no pressure is made upon the dura underneath. In this manner the dura is freely exposed over the desired area. (Figs. 16, 17, 18, 19.) In the cervical and dorsal regions the dura is covered by a thin layer of adipose tissue which has to be excised before the bluish

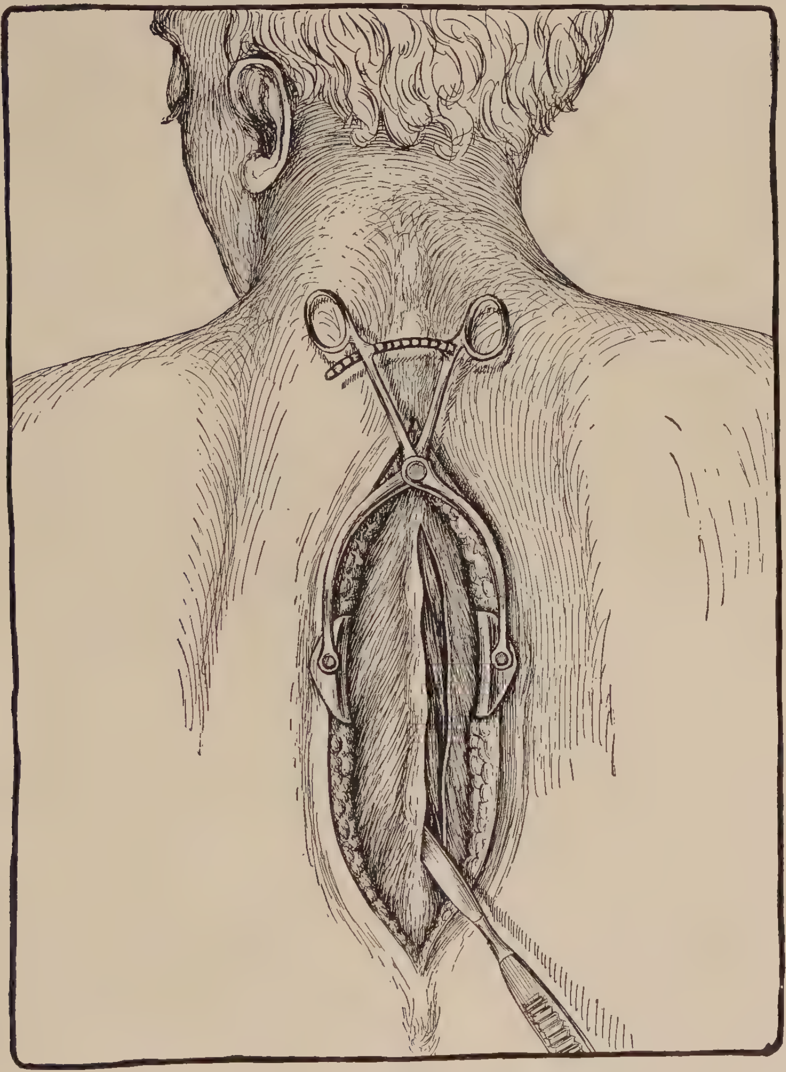

FIG. 16.—LAMINECTOMY (1). The first step. Incision of the skin, fascia and muscles on one side of the spinous processes.

dura is exposed, while in the lumbar region the thick ligamenta subflava have to be excised with scissors and forceps.

The further procedure will depend upon the nature of the affection for which the laminectomy has been performed.

It is usually necessary to pack the wound with gauze wrung out in hot saline solution for a few minutes in order to control the little oozing of blood from the divided laminæ; the dura should never be incised before every bit of bleeding has been controlled. Then the operator carefully palpates the dura if he suspects a spinal tumor, and looks for the respiratory and cardiac pulsations.

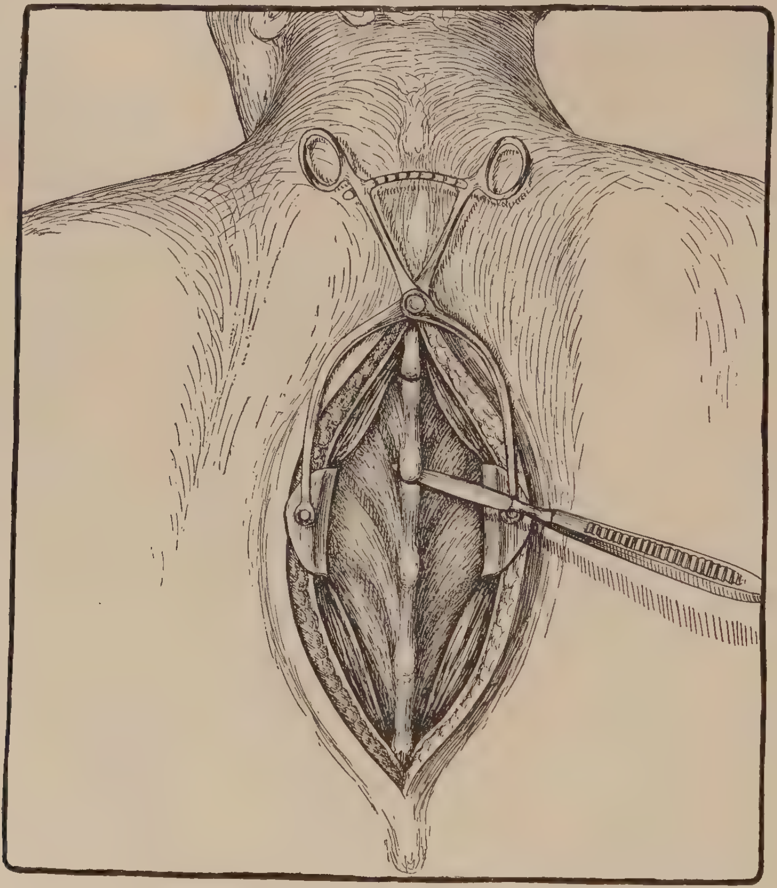

Fig. 17.—Laminectomy (2). The division of the interspinous ligaments.

When the dura is to be incised the operator grasps a small bit of dura with fine forceps, and passes a traction suture of fine silk on each side of his forceps. The needle should pass through only part of the thickness of the dura so as to avoid the arachnoid and the cord beneath. The 2 traction sutures are now held tense, and the dura carefully incised with a fine scalpel. If this is skillfully done, the arachnoid sac will not be injured; it is distended with fluid, within which lies the cord. The incision in the dura is then enlarged upward and downward by means of a grooved director and scalpel, and the edges of the dura retracted with fine 2-pronged retractors. The further procedure will depend upon the conditions present or the nature of the operation to be performed, and will be considered under the various sections that are to follow.

The dura should be closed by means of a fine running suture of silk after all oozing within the arachnoid sac has been controlled. The automatic retractor is then removed, the wound washed out with warm saline solution, and the muscles united by interrupted sutures of strong catgut. At least 2 layers of muscles have to be united, and sometimes 3 layers, great care being taken that the upper and lower ends of the wound are well closed. The fascial edges are then approximated with chromic catgut, and the skin with silk sutures. A laminectomy wound should never be drained. A large, firmly fitting dressing with adhesive plaster straps and bandage is then applied. The patient should be kept flat on the back for several days after the operation, and for at least 1

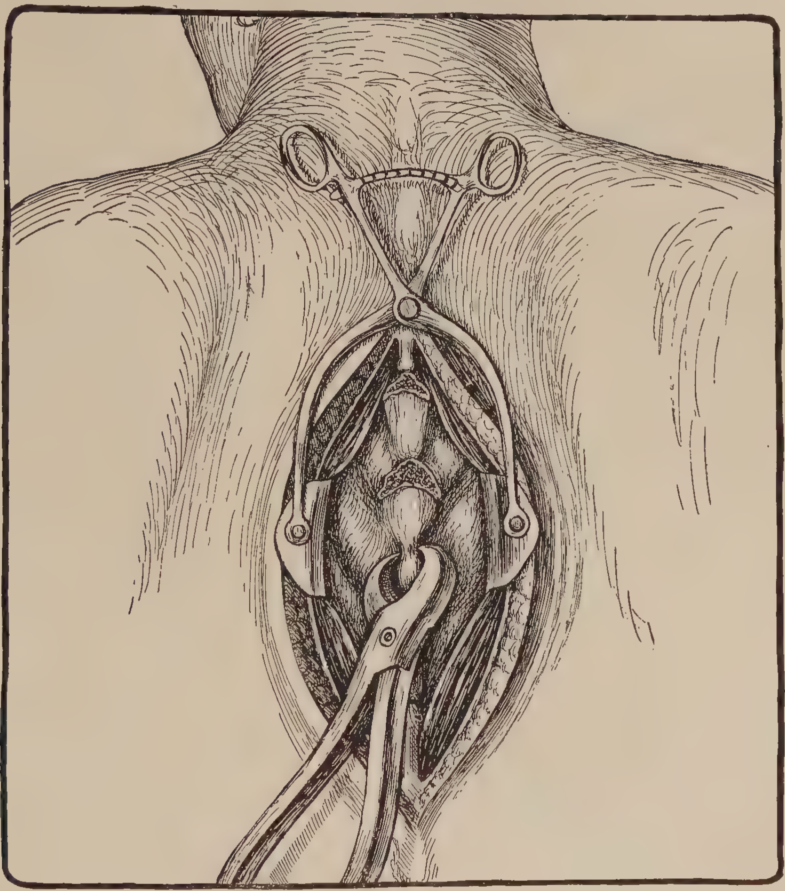

FIG. 18.—LAMINECTOMY (3). The removal of the spinous processes with giant rongeur forceps.

week should receive full doses of urotropin. Unless there are special indications for it, the dressings should not be disturbed for 7 to 10 days.

Other operative methods which have been recommended for opening the spinal canal have either been of the type of osteoplastic operation devised by Urban and Bickham, in which a flap containing skin, muscle, and bone is made and turned to one side or upward; or the operation of hemilaminectomy, as recommended especially by A. S. Taylor, of New York. The osteoplastic methods have been generally discarded, because the operations are more bloody and time-consuming and more apt to be followed by wound complications. In the operation of hemilaminectomy the muscles are separated from the spinous processes and laminæ on only one side, and the laminæ on that side removed from the bases of the spinous processes to the articulations either with the saw or with rongeurs. Taylor claims that almost as good an exposure can be obtained through a hemilaminectomy as in the complete laminectomy, and that

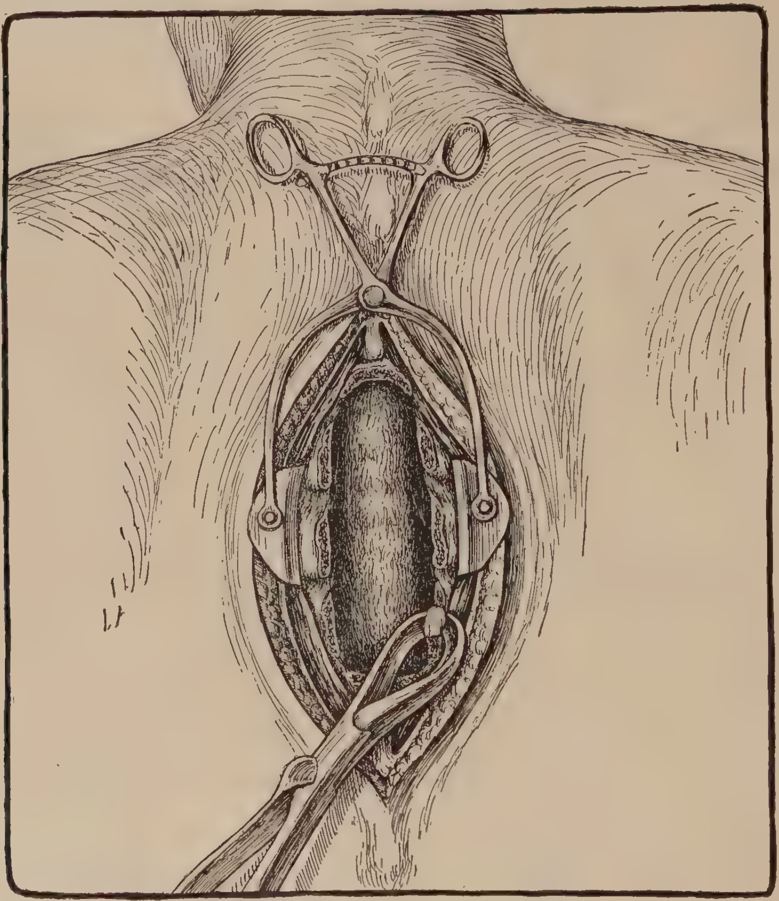

FIG. 19.—LAMINECTOMY (4). The laminæ have been removed and the dura exposed. (Figs. 16 to 19 are modified from illustrations in Chirurg. Operationslehre, Bier-Braun-Kümmel, i.)

the mechanics of the spine are much less interfered with. Without entering into a discussion of the first of the 2 advantages claimed for his operation by Taylor, I believe that the second claim is a theoretical one. I shall later show how little the functions of the spine are interfered with (if at all) by even an extensive laminectomy, and I believe that a hemilaminectomy is rarely indicated.

Dangers and Difficulties of the Operation.—In the cervical and upper dorsal regions the operation is never difficult, while in the lowest dorsal and lumbar regions, where the vertebral arches are much thicker and more deeply placed, considerable rongeuring may be necessary before a good exposure of the spinal canal and its contents has been obtained. Care must be taken by the inexperienced operator that he does not deviate from the median line.

LEAKAGE OF CEREBROSPINAL FLUID.—Much has been written concerning the dangers from the sudden escape of a large amount of cerebrospinal fluid when the dural sac is opened. In a large experience with these operations I have never seen symptoms ensue from this cause. Nevertheless, it is advisable to lower the head end of the operating table if there is a profuse escape of fluid.

If the dura has been well closed after the operation, leakage of cerebrospinal fluid should never occur. If a 2-stage operation is done and the dura is not sutured at the first operation, the careful suture of the muscles and fascia should prevent any leakage. If leakage does occur, the dressings should be changed as often as necessary with the greatest care as to asepsis, the skin being painted with tincture of iodin as soon as the dressings are removed.

BLADDER DISTURBANCES.—Even if no bladder disturbances existed before the operation, they are very likely to occur afterward. Usually there is retention of urine for a few days; rarely this persists for several weeks. When the laminectomy has been done in the lumbosacral region, the retention is accompanied by a lack of feeling of bladder retention; after an operation in the cervical or dorsal region, the patient will often know when his bladder is distended. When the patient regains control of his bladder, he is at first able to empty the bladder only partly. Unless incontinence existed before the operation, it should rarely occur afterward. If such incontinence does occur, it usually means that some injury has been done to the cord, or that there has been considerable bleeding within the sac of the arachnoid. If the incontinence is due to the latter cause, it will usually disappear within a few days or weeks; if due to the former, it may persist for months; and if the injury to the cord has caused a more or less complete transverse lesion, it may be permanent.

After the removal of a tumor or other disease of the cauda equina which has caused retention of urine as one of the symptoms, the retention of urine may persist for a number of months. In these patients one can often stimulate the bladder to empty itself by suddenly removing the catheter during catheterization, the patient being told at the same time to attempt to void his urine with the catheter in place.

ABDOMINAL DISTENTION.—Abdominal distention may occur after a laminectomy as after any other operation. But it occurs very frequently after a laminectomy in the lower dorsal region. After a spinal operation at this level, a very marked and, to the patient, very distressing abdominal distention often occurs, which can be only partly relieved by cathartics or enemata, and which usually persists for several days. The patients are unable to pass any gas, the abdomen becomes enormously distended, and vomiting occurs, so that, to one who has not seen the condition, the patient seems to present the clinical picture of acute intestinal obstruction. The symptoms, however, usually subside within a few days.

Recognition of Spinal Lesions.—Those most experienced in spinal surgery often find much difficulty in recognizing the nature of the changes which are found at operation. A few words upon the normal and pathological appearance of the spinal cord and membranes are, therefore, permissible.

Normally the outer surface of the dura has a bluish-white color and is smooth and glistening. A reddish or brownish discoloration is due to adjacent bone disease or to an inflammatory process in the dura itself. To the examining finger the membrane feels soft and it is easy to recognize that it is thin and contains fluid. If the finger is gently passed over its surface, one can often (but not always) feel if a solid mass such as a tumor lies under it, and an intradural growth will sometimes cause a distinct bulging of the dura. A similar bulging and a similar resistance are felt when the cord has been pushed backward by an affection of the vertebræ or by a tumor which lies in front of the cord. The surgeon must, therefore, be careful that he does not injure the growth or the cord when he incises the dura.

In rare instances a localized pachymeningitis may cause a marked bulging of the dura because of the great thickening of the membrane. I have seen one case in which a marked local thickening gave all of the symptoms and upon operation presented all of the characters of a spinal tumor until the dura had been incised.

The inner surface of the dura should be smooth and shiny. If it is congested or discolored, it is the seat of an inflammatory process.

The arachnoid should be translucent and very thin. If it is thickened or whitish in color, it has been the seat of a leptomeningitis. The arachnoid is sometimes distinctly thickened if long pressed upon by a tumor.

The posterior surface of the spinal cord should be covered by a fine network of blood-vessels, but normally these should not be sufficiently marked to cause a change in the creamy white appearance of the cord. If the vessels are very large and tortuous, giving to the cord a pinkish color, it means that there is either an inflammatory process within the cord substance or pressure upon the vessels of the cord at a higher level than that exposed. In several cases of myelitis which were operated upon under a wrong diagnosis I have observed a marked congestion of the posterior spinal vessels of quite a characteristic appearance. Such a marked vascularity of the cord has led me, in not a few instances, to search for a suspected tumor at a higher level than that exposed.

Frequently, however, one can normally see masses of tortuous vessels near the lateral aspects of the cord at points where the nerve roots perforate the dura.

While it should be a rule that the cord is to be palpated as little as possible, the surgeon should know that normally the cord substance feels fairly solid, and that, therefore, irregularities can easily be recognized by the examining finger.

Two-stage Operations.—Several surgeons have advised that many laminectomies should be done in two stages, the dura being exposed at the first sitting. I believe that the larger number of patients can be operated upon in one stage. If the condition of the patient should become too poor, then an operation may have to be stopped and be continued at a later time. This should, however, be of rare occurrence.

Two-stage operations are indicated in the following: In all intramedullary operations for tumor where the tumor is left to extrude from the cord after an incision into the cord tissue has been made; in operations in the uppermost cervical region, to allow of a re-adjustment of pressure conditions on account of the proximity of the medulla; in some cases of large tumors of the conus and cauda equina, where a delay may allow the tumor to become partially freed from the nerve roots of the cauda; in some subpial tumors to be treated by the method of extrusion. In the case of high cervical operations the dura must not be opened at the first stage; in the other operations above mentioned the dura will have to be opened at the first stage, and will have to be left open until the second operation. In these latter cases the exposure of the cord and tumor at the second operation will be made more easy if they have been covered by a piece of Cargile membrane at the first operation.

Functions of the Spinal Column after Complete Laminectomy.—From the esthetic standpoint the appearance of the back of a patient who has had a laminectomy performed upon him is very satisfactory. In most cases, excepting for the linear cicatrix, the contour of the back appears almost normal. The mass of the paravertebral muscles and the scar tissue that is formed between the divided laminæ and the skin form a good support for the skin and an excellent protection for the spinal cord beneath.

The free mobility of the spinal column is usually fully recovered. For a number of days after the operation the spine is held very rigid, because of the pain which follows movements of the head, trunk, or extremities. As soon as the pain disappears the patients are able to turn freely, and within 10 to 14 days they are able to sit up and begin to walk. Considerable stiffness and rigidity of the spine may persist for several months, and this occurs especially after lumbar laminectomy. In most patients, after an operation upon the cervical vertebræ, the mobility of the spine is fully regained within 2 to 3 weeks. Some of the patients have a tendency to carry the head somewhat forward, as if there had remained some weakness of the cervical spinal muscles. Very rarely massage and exercises are necessary before the vertebral column regains its normal mobility. Six months after a laminectomy has been done the vertebral column will be found as freely movable as the normal, or as it would have been in the individual case if no operation had been performed.

Mortality of the Operation.—It is difficult to obtain a satisfactory idea of the mortality due to the operation of laminectomy, because the results vary with the affections for which the operations are done. The statistics of different operators vary within wide limits. Spinal surgery can only be successfully performed by those who have a large experience in this special branch of surgery. Oppenheim has reported 25 operations performed for him by several surgeons with 8 fatalities from the operation. Krause had 28 operations with 8 deaths; in a later publication he stated that, exclusive of laminectomy for spinal fracture and cases of myelitis, he had performed 45 operations with 9 deaths. Hildebrand had 35 laminectomies with 9 deaths; Nonne had 13 operations with 7 deaths; Sick had 21 cases and 8 deaths.

On the other hand, Horsley reported 24 successive cases without fatality, and Oppenheim justly states that the dangers of a laminectomy are small when the operation is done by a surgeon of the experience of Sir Victor Horsley.

The above statistics refer to all the spinal operations performed by the authors quoted, excepting laminectomies for fracture of the spine and the cases in which myelitic softening was found at operation. Excluding operations for the condition just mentioned, I have, up to October 1, 1913, performed 81 laminectomies with 4 operative deaths (4.9 per cent.), and have had no fatal case in the last 57 operations.

In many instances the fatal result of a laminectomy was due to the undue prolongation of the operation. With proper instruments the removal of 3 or 4 spinous processes and laminæ should not require more than 10 to 30 minutes. Some of the deaths have been due to loss of blood, but the hemorrhage during a spinal operation should seldom, if ever, be large in amount if the manipulations are not unduly prolonged.

LAMINECTOMY FOR TUMOR OF THE SPINAL COLUMN AND CORD

In the majority of instances tumors of the vertebral column are metastatic from some other part of the body or are extensions from disease of the adjacent soft parts. Benign growths, such as osteoma, chondroma, or exostosis, are of very rare occurrence, and in only a very few instances have they been subjected to operation. The malignant growths, on the other hand, are very frequent, and the symptoms to which they give rise are most distressing, so that they are justly considered one of the most terrible ills that human flesh is heir to. Many attempts have been made to operate upon primary new growths of the bony spine. But the results have been most unsatisfactory because it is seldom, if ever, possible to eradicate the disease entirely; the cord symptoms usually progress uninfluenced by the operative interference. Most of the patients have been operated upon because the diagnosis was uncertain; in many of the cases the operation was discontinued as soon as the real condition was recognized.

Metastatic malignant disease of the spine should never be operated upon; the disease usually affects the bodies of the vertebræ primarily. A laminectomy may, however, be indicated in some cases of primary or metastatic disease of the spine where the horrible sufferings of the patient are to be relieved by division of sensory posterior roots or division of tracts of the cord which carry the painful sensations.

If the diagnosis of a malignant affection of the spine has been made, it is advisable, in most cases, to refrain from any surgical interference. Immobilization of the spine by means of a plaster jacket and morphin are the only means we can use to relieve the patient for his short span of life. There are some cases in which the progress of the disease is very slow, and the sufferings so acute, in spite of morphin, that the attempt has been made to relieve the patient by the intradural division of a large number of sensory nerve roots. The results from this operation have not been satisfactory; when improvement occurred, it was only evanescent. The technic of the operation of section of posterior roots will be considered later (page 717).

DIVISION OF THE ANTEROLATERAL TRACTS OF THE CORD

About 3 years ago (1911) Spiller and Martin recommended the division of the anterolateral tracts of the cord, the tracts which convey the sensations of pain to the higher centers, for the relief of intractable pain from malignant disease of the spine. The operation was performed once by Martin, of Philadelphia, once by Beer, of New York, and once by me. Spiller and Martin's patient was relieved for a time; Beer's patient had almost complete relief for several months; in my case the relief was only of a few days' duration. The future will have to show whether the results will justify the operation.

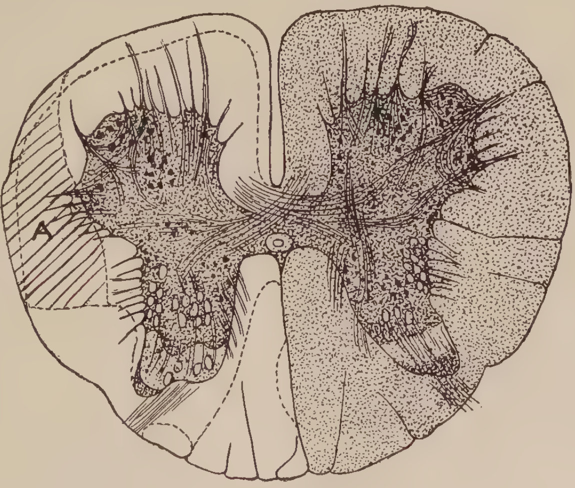

Fig. 20.—Cross-section of Spinal Cord to Show the Anterolateral Tract (A) of the Left Side.

For the division of the anterolateral tracts of the spinal cord (Fig. 20) laminectomy is done well above the level of the lesion, the spines and laminæ of 2 vertebræ being removed in the usual manner. After the dural sac has been opened, the cord is rotated to one side by means of traction on a slip of the dentate ligament. About 2 or 3 mm. in front of the origin of the posterior root an incision 2 or 3 mm. in length and 2 or 3 mm. deep is made in a transverse direction with a fine scalpel. If the pain from which the patient suffered was bilateral, the anterolateral tracts of both sides must be divided; otherwise, only the tract on one (the opposite) side.

Further experience will have to show whether the operation will be successful in relieving the pain in every case, and whether the relief will be of long enough duration to justify this palliative operation. In this connection it is to be remembered that patients with primary malignant disease of the vertebræ or soft parts often stand the anesthesia and operation very badly, while those with metastatic disease stand the operation much better.

REMOVAL OF EXTRADURAL TUMORS

Extradural tumors of the spine, originating from the outer surface of the dura and not affecting the surrounding bony or soft tissues, are occasionally met with. The removal of such a tumor is a very simple procedure. As soon as the laminæ have been removed, the tumor comes into view and it can usually be peeled off from the dura without difficulty. If the growth is intimately connected with the dura, a piece of dura must be excised with the tumor, and the dural sac then closed by suture. If the tumor lies on the lateral side of the dura, as in one case that I have operated upon, it may be necessary to divide one posterior root before the growth can be removed. It is not necessary or advisable to unite the ends of the divided posterior root after the removal of the tumor.

REMOVAL OF INTRADURAL GROWTHS

It is often possible to recognize that a tumor is present by palpation through the dura after the dura has been exposed by the laminectomy. Small subpial growths and growths on the anterior and lateral sides of the spinal cord cannot be felt through the intact dura, and the operator should never fail to open the dural sac widely in the search for a spinal new growth. In the search for the tumor the edges of the incision in the dura must be held well apart by means of small 2-pronged retractors.

The surgeon first watches the cord closely to determine whether the cardiac and respiratory pulsations are present. A normal cord presents both cardiac and respiratory movements in the great majority of instances, although occasionally the pulsations are wanting for a time after the sudden escape of a large quantity of cerebrospinal fluid.

If the dura has been incised without injury to the arachnoid, the arachnoid sac will be seen distended with clear fluid, and very often the reddish or bluish tumor will be seen. If there is very little fluid within the sac, or little escapes when the arachnoid is incised, there must be an obstruction somewhere above this level.

The arachnoid is now incised with a fine scalpel, and if the tumor has not been found, it must be searched for. If the cord is of normal size and consistency, the lateral and anterior aspects must be examined. The cord must be carefully pushed to the one and the other side by means of a thin instrument, extreme care being taken that as little pressure as possible is made upon the delicate cord tissue. In order to examine the lateral recesses, a slip of the dentate ligament on each side must be grasped with mosquito forceps, divided near the dural attachment, and the cord then drawn to the one and the other side by means of traction on the forceps (Fig. 22). By means of traction on 1 forceps the cord can be rotated so that its anterior surface can be inspected. Unnecessary to state, the cord should not be handled with the fingers; the operator should consider that every time he touches the cord he is doing harm to it. If the tumor is not found, a small probe should be carefully passed upward and downward in front of and behind the cord to determine whether any obstruction exists. A slight obstruction may, however, be due to the end of the probe coming in contact with a nerve root or slip of the ligamentum dentatum.

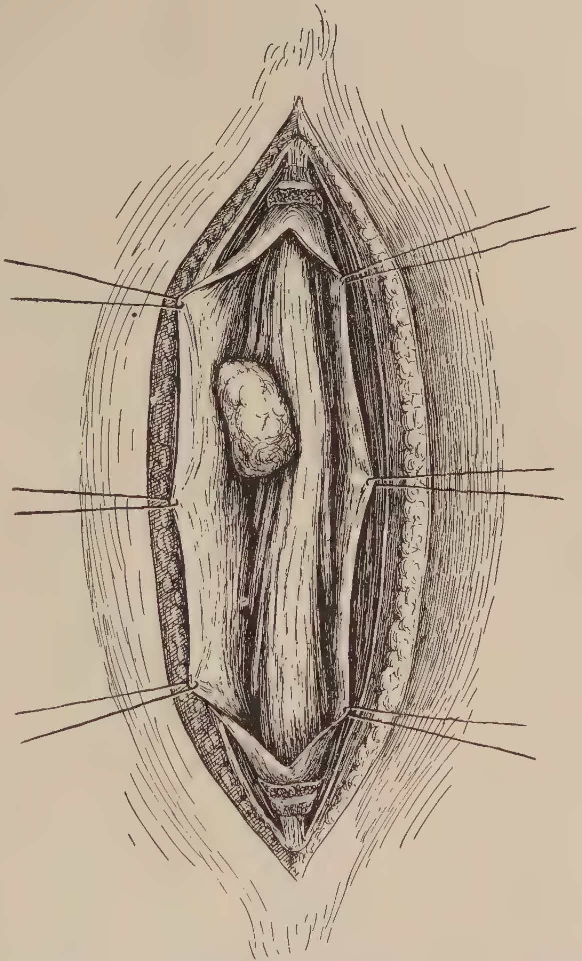

Fig. 21.—An Extramedullary Tumor on the Posterolateral Surface of the Cord.

As soon as the tumor has been found we proceed to its removal. Most of the extramedullary growths lie superficial to the pia and are attached to it by flimsy adhesions; some, however, lie underneath the pia mater, so that the pia has to be incised before the growth can be removed (Fig. 23).

The upper and lower ends of the tumor must be well exposed; one should never hesitate to remove more bone if the exposure is not a good one. If the growth lies on the posterior surface of the cord, it must be carefully raised away from the cord and the

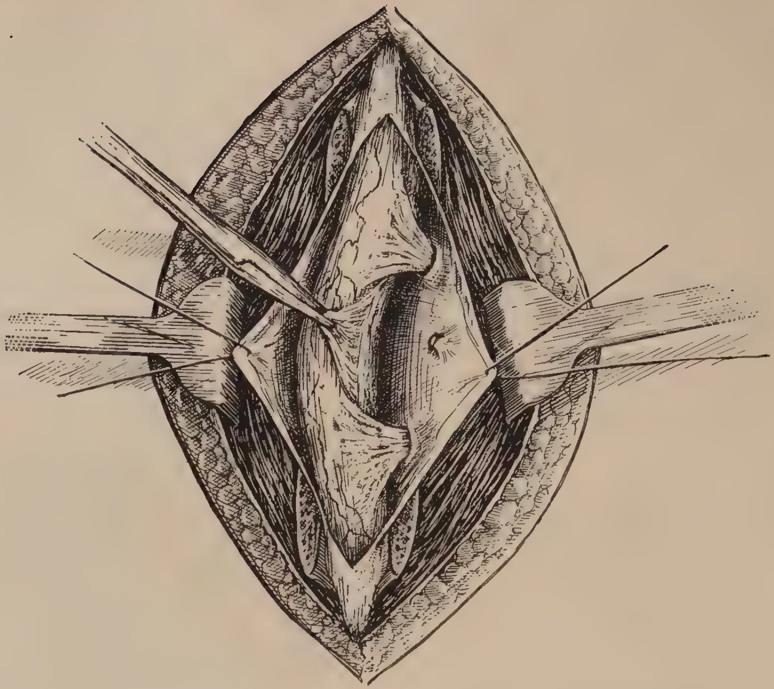

Fig. 22.—Procedure for Exposing the Anterior Surface of the Cord.

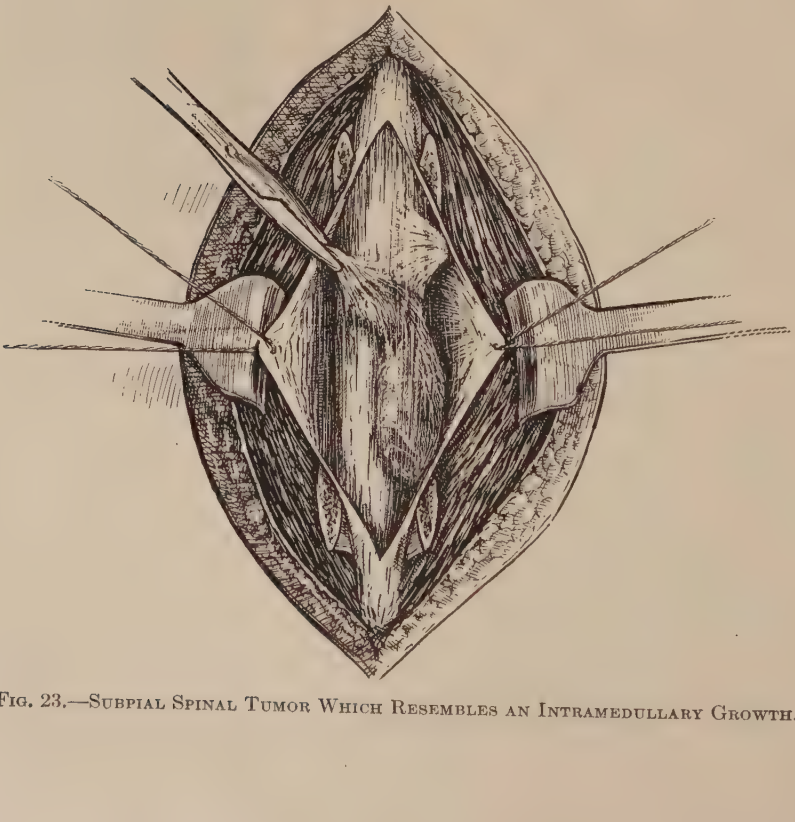

Fig. 23.—Subpial Spinal Tumor Which Resembles an Intramedullary Growth.

fine adhesions to the pia divided. Great care must be taken not to cause the slightest injury to the cord tissue, and if it is found that the tumor is intimately connected with the cord, an entirely different procedure must be adopted (see Intramedullary Tumors).

Any small blood-vessels must be ligated with very fine silk and divided. The slightest oozing must be controlled by gentle pressure with bits of cotton or by gentle irrigation with warm saline solution before the dura is closed.

If the growth lies on the lateral surface of the cord, it is often necessary to divide a slip of the dentate ligament before the tumor can be removed; sometimes it is necessary to divide 1 or 2 posterior roots which run through the tumor. If the growth is firmly adherent to the inner surface of the dura, a piece of that membrane must be excised with the growth. The dura must always be tightly closed after all oozing has been controlled, and should never be drained.

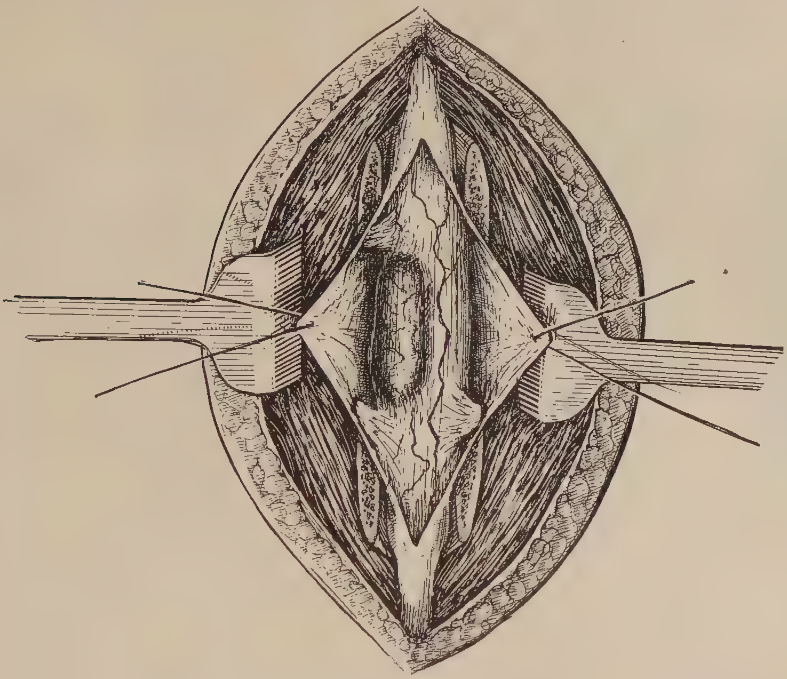

Fig. 24.—Subpial Spinal Tumor Lying in a Cavity in the Cord.

If the surgeon has to deal with a tumor which lies outside of the cord tissue proper, but in or beneath the pia mater, he may have to vary his procedures from the method just described. Should there be adhesions to the cord tissue, no attempt should be made to remove the tumor at this stage, but the actual removal should be delayed until later, and the tumor should be treated according to the principles which will be laid down (page 702) for the treatment of intramedullary growths.

Special Procedures at Different Levels of the Cord.—When a growth is exposed high up in the cervical region it is advisable to divide the operation into 2 stages, at the first only exposing the growth; at the second stage, which should be done in 6 to 7 days, when the pressure conditions have re-adjusted themselves and the danger to the medulla oblongata has been lessened, the tumor can be removed with safety.

Special care must be taken in the removal of a tumor of the conus or from between the roots of the cauda equina. It is still an open question whether the giant tumors of this region (giant endotheliomas) (Collins and Elsberg), which fill up the entire lower part of the spinal canal, should be removed. These tumors are usually of very slow growth, and give distinct symptoms only after they have attained a large size, surrounding the caudal nerves. In their removal, even if it is done in 2 stages, a great deal of injury is done to the nerve roots from which the growth is separated. Especial care must be taken not to injure the filum terminale with which the nerve runs to the bladder.

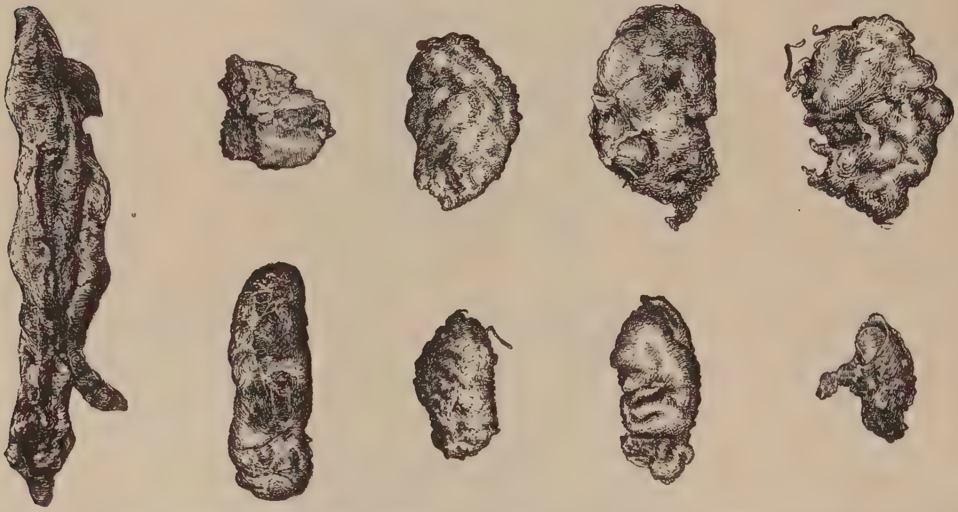

Fig. 25.—Extramedullary Tumors Removed at Operation. The long growth is typical of the so-called giant endotheliomata of the cauda equina.

Small tumors between the roots of the cauda equina can usually be removed without difficulty; they are, however, of relatively rare occurrence compared with tumors in other parts of the spinal cord.

RECOGNITION OF INTRAMEDULLARY TUMORS OF THE CORD; TECHNIC OF ASPIRATION AND INCISION OF THE CORD, AND REMOVAL OF INTRAMEDULLARY TUMORS BY THE METHOD OF EXTRUSION

A complete laminectomy is always necessary when a thorough exploration of the cord is to be made. It should never be difficult to recognize a tumor that lies underneath the arachnoid, for these growths always lie behind and superficial to the pia mater. It is not so easy, however, to differentiate between a subpial growth closely adherent to the cord (Figs. 23 and 24) and a true intramedullary neoplasm, especially if an intramedullary tumor has broken through the posterior surface of the cord and has pushed the pia mater before it. After the operator has incised the pia covering the tumor, he may think that he is incising cord tissue when in reality it is the capsule of the tumor. With some experience, one soon learns to recognize the soft creamy yellow cord tissue. Careful palpation of the cord will often inform the surgeon that he has to deal with a solid tumor within the cord substance or that the enlargement is due to a collection of fluid. The majority of intramedullary tumors cause a fusiform enlargement of the cord (Fig. 26).

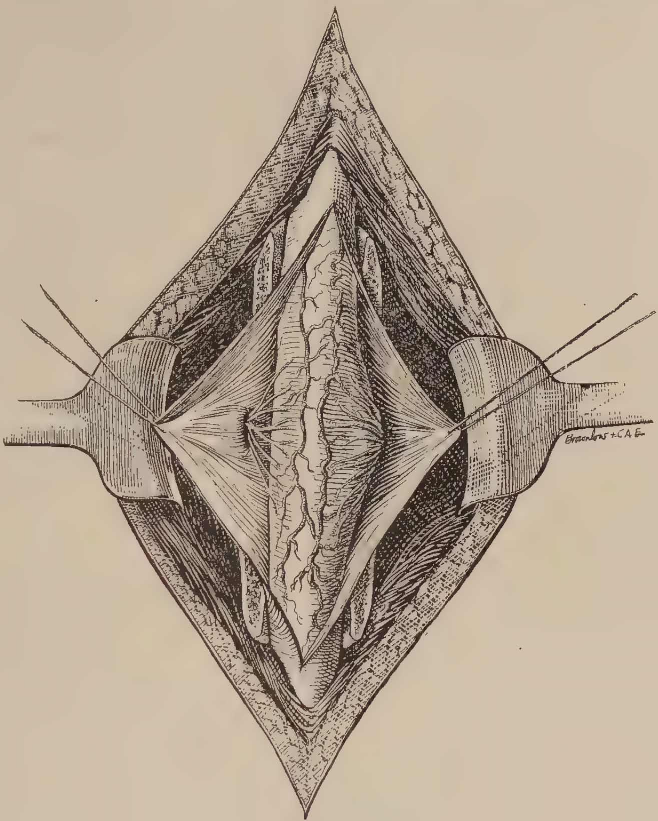

Fig. 26.—Fusiform Enlargement of the Cord Due to Intramedullary Spinal Tumor.

As soon as the cord is exposed, and the surgeon has determined that a growth exists within the cord, he must at once proceed to its removal. Before describing the exact procedure to be followed, a few remarks upon the anatomy of the cord and the technic of aspiration and incision of the cord tissue must be made.

Based upon anatomical and physiological considerations, I have shown that it is perfectly feasible and safe to incise the cord, and further that the location of the incision is to be made in the posterior columns near the posterior median septum (Fig. 27).

Puncture of the Cord.—The cord can be punctured with entire safety with a needle, provided only the finest aspirating needle is used, and care is taken not to injure even the smallest vessels which enter the cord through the posterior median septum or run in the pia mater. In doing the aspiration it is advisable to make the puncture **near but not through** the posterior median septum. The cord must be carefully steadied, as the pia offers some resistance to the entering needle. A slip of the dentate ligament is grasped on each side with fine mosquito forceps and held in place. Extreme care must be taken that the direction of the needle is held constant. Needless to add, the cord must never be grasped with an instrument or with the fingers.

Incision of the Cord.—For the incision of the cord a very fine scalpel, such as the von Graefe knife used by the ophthalmologist, should be used. The arachnoid is first incised and grasped with fine forceps. Then the proper part of the posterior column is selected and an incision made. The incision must be carefully deepened and enlarged, care being taken that it shall be in the long axis of the cord. The enlarging and deepening is best done with a blunt instrument, and for this purpose a small blunt strabismus hook is the proper instrument. The incision in the cord should always be slowly made and should be stopped as soon as there is the slightest bleeding. Sponging should be done with small bits of cotton, with extreme gentleness, so as to make the smallest amount of pressure upon the cord. When a cystic collection of fluid or a small area of softening is opened, no effort should be made to remove the fluid in the cavity by sponging or by pressure.

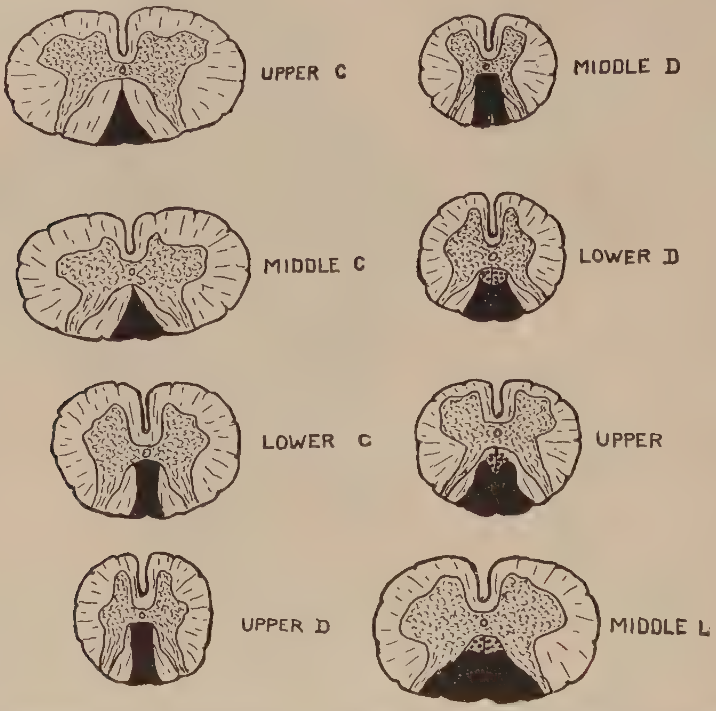

Fig. 27.—Cross-sections of Spinal Cord at Different Levels. The areas in the posterior columns in which ascending degeneration occurs after injury to the sacral and lower lumbar posterior roots of both sides (after Schultze). Within these areas, shaded in black, an incision can be made which will cause little injury and few, if any, symptoms.

Removal of the Growth.—The attempt to remove a growth from within the substance of the spinal cord, no matter how carefully it was done, would require an amount of handling and a degree of manipulation of the delicate tissue of the cord that would in the large majority of cases be followed by a traumatic inflammation that would damage or destroy all the elements of the cord at the spot and would probably be permanent in its effects. Therefore, although intramedullary growths had been removed in a very few instances with more or less improvement, it was necessary to devise a new method for these intramedullary growths. In 1911 Elsberg and Beer described the method of extrusion by means of which it is possible to remove a tumor from the substance of the cord with a minimum amount of injury to the cord tissue.

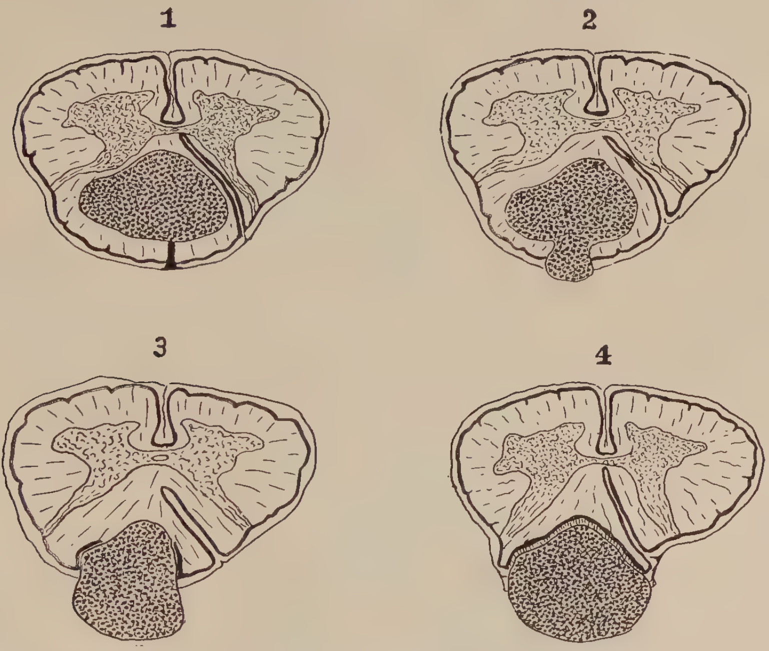

Fig. 28.—The Extrusion of an Intramedullary Tumor After the Incision Into the Cord Has Been Made. (Diagrammatic.)

The theory upon which the method of extrusion is based is the following: There must exist within the cord a certain intramedullary pressure, such as exists in all solid and fluid substances. When there is a tumor growth in a part of the cord, the intramedullary pressure must be locally increased. If an incision is made down to the growth, nature will proceed to readjust the pressure conditions, and in so doing will push out, conditions being favorable, whatever has caused the local increase of pressure. When, therefore, an incision is made down to the tumor in the cord, the tumor will be slowly pushed out of its bed, and will be slowly "extruded" from the cord substance. Nature will accomplish this process slowly, nerve fibers being slowly pushed to the sides while the growth is being extruded, and with far less injury to the cord structure than the most careful manipulations of the surgeon. If these theoretical considerations

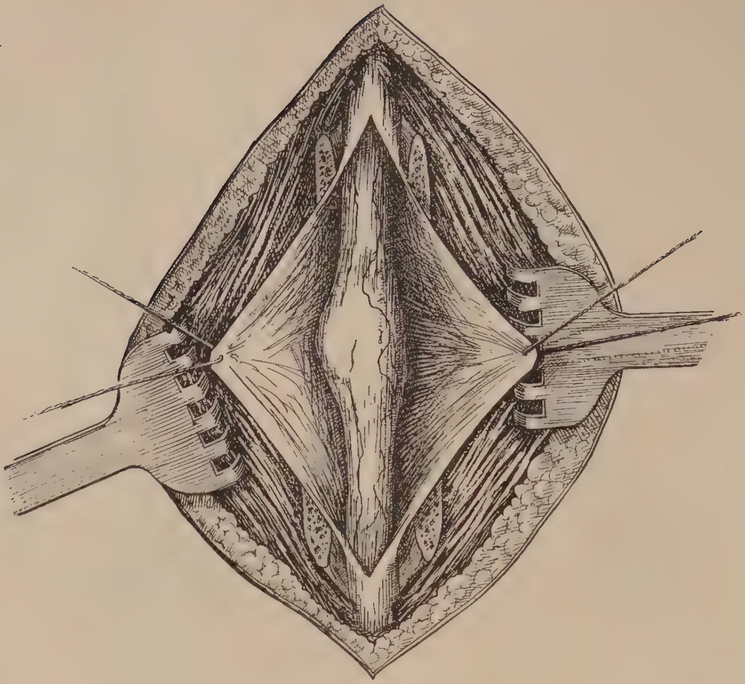

FIG. 29.—FUSIFORM SWELLING OF THE CORD FROM AN INTRAMEDULLARY TUMOR.

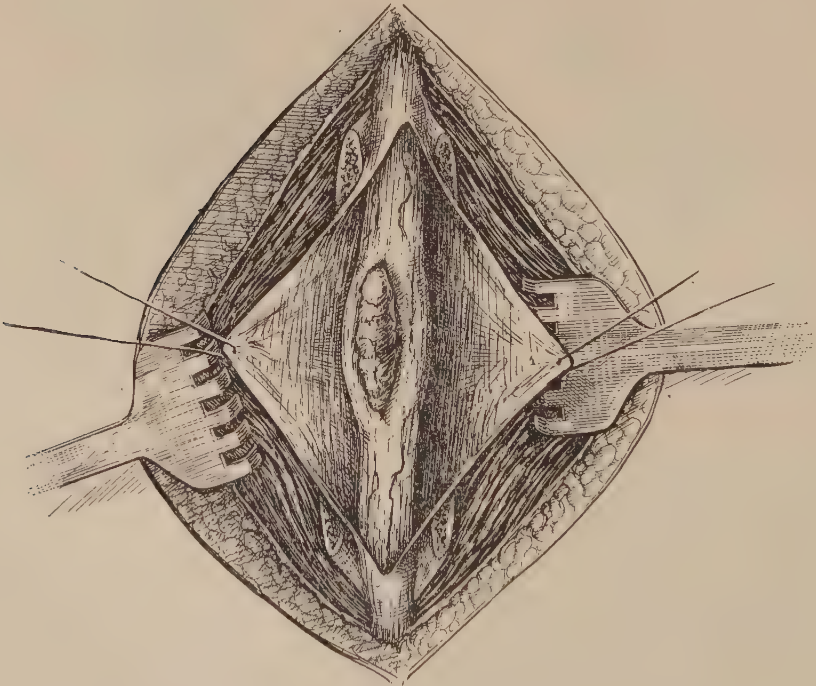

FIG. 30.—PARTIAL EXTRUSION OF THE INTRAMEDULLARY TUMOR AFTER INCISION OF THE CORD.

were correct, the surgeon would only have to incise the cord down to the tumor, and then have to wait for the readjustment of pressure conditions when the tumor should be found outside of the cord tissue. The practical trial of this method showed that the theory upon which the method was based was correct and we have called the procedure "the method of extrusion."

If, then, after laminectomy and incision of the dura, the surgeon finds that he has to deal with an intramedullary growth, he should make a short incision about 1 cm. in length in the posterior median column, a few millimeters outside of the posterior median fissure, at the spot where the growth seems to be nearest the surface of the cord. The incision, made in the manner we have already described, should be deep enough to divide the pia and the substance of the column down to the tumor. The tumor will then begin to bulge through the incision. No matter how markedly the tumor protrudes, the surgeon must not attempt to remove the growth for fear of grave injury to the cord. The operation must be concluded for the time being, the dura left wide open, and the muscles, fascia, and skin carefully closed, as if the operation was definitely ended. The actual removal of the tumor is left for a second operation.

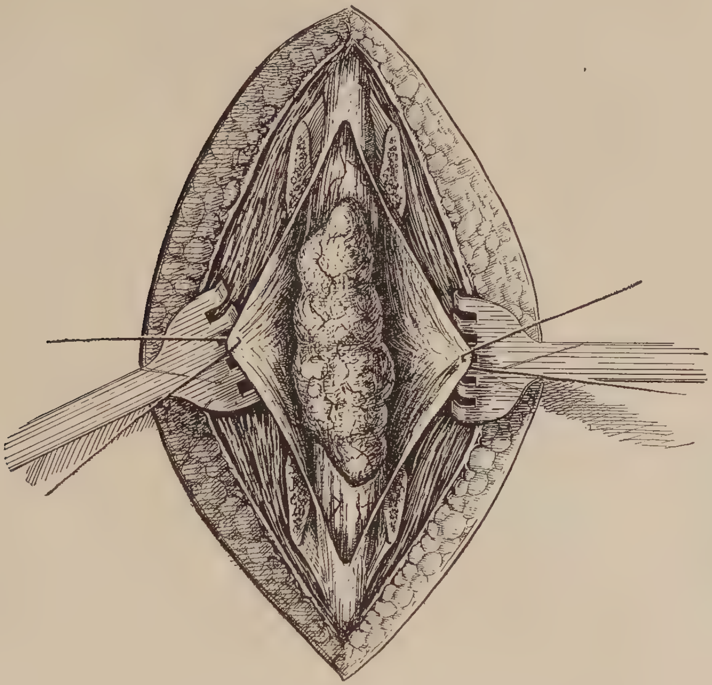

Fig. 31.—Complete Extrusion of the Intramedullary Tumor One Week After Incision of the Cord.

After about a week the wound is re-opened, and the tumor, which will in all probability be found outside of the cord, can be removed by dividing the few adhesions which remain. When the tumor has been removed, and all bleeding controlled, the dura, muscles, fascia, and skin are closed in the usual manner (Figs. 29, 30 and 31).

If, at the second operation, the tumor is found to be still closely connected with the cord tissue, it is advisable to leave it in situ and not to attempt its removal.

Thus far I have spoken of localized intramedullary growths. In the case of intramedullary growths which extend over a large number of cord segments, and which infiltrate the cord tissue, a small incision in the cord at the level of most marked symptoms may allow of the partial extrusion of the tumor with amelioration of the patient's symptoms.

Failure to find the growth may be due to several causes. The foremost of these is error in the diagnosis of the level, but this should rarely occur. The advances in the knowledge of the level signs of spinal tumors have been very large, and the competent neurologist or neurological surgeon should be able, in the large majority of instances at least, to diagnosticate the level correctly.

The surgeon may fail to find the tumor because he has opened the spine at the wrong level. It is always safest to remove the spines and laminæ 3 vertebræ higher than the level symptoms. Thus, if the signs point to the involvement of the eighth dorsal spinal segment, the surgeon should remove at least the fifth and fourth spines and laminæ. In the cervical region it usually suffices to operate 2 vertebræ higher, while in the dorsal and lumbar regions one must go at least 3 vertebræ higher.

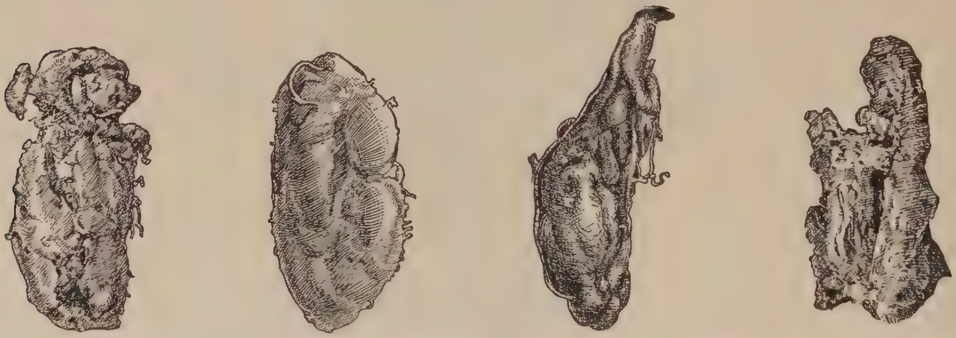

FIG. 32.—INTRAMEDULLARY TUMORS REMOVED FROM THE SPINAL CORD BY THE METHOD OF EXTRUSION.

If very little cerebrospinal fluid escapes when the dura is opened, one must be suspicious that an obstruction exists above the level of the operation, and the surgeon must carefully probe the canal both in front of and behind the cord for the location of the obstruction. Experience will teach the operator to distinguish between the obstruction to the passage of the probe due to its contact with a nerve root or a slip of the dentate ligament, and the elastic resistance offered due to a tumor. If slight pressure against a resistance is followed by the sudden escape of cerebrospinal fluid, which ceases as soon as the pressure is released, one may be certain of the presence of a tumor. I have, in not a few instances, been able to determine that a tumor existed 3, 4 and even 5 inches above the exposed part of the spinal cord by this procedure.

RESULTS OF SURGICAL TREATMENT OF TUMORS OF THE SPINAL CORD

There is no more satisfactory operation in surgery than the removal of an extramedullary tumor of the cord. The patients usually stand the operation very well, if it be done rapidly, and recovery is prompt. The recovery from the paralytic and other symptoms will occur very rapidly if the case has come to operation early. I have seen complete recovery in 3 to 4 weeks. If the case has been a far-advanced one, recovery will be very slow, requiring many months or years. If the cord has been injured by the long pressure of the tumor, some of the symptoms may never be recovered from. The mortality from the operation has varied in the hands of different operators. Thus Horsley operated upon 20 successive patients without a death; in 26 operations by Fedor Krause, there was a mortality of 37 per cent. Harte collected records of 92 operations for spinal tumor with an operative mortality of 47 per cent. McCosh claimed that the mortality should not exceed 10 per cent. I have removed 15 extramedullary tumors, with 1 death 8 weeks after the operation.

Intramedullary tumors have been removed with great improvement in the symptoms by Ropke (1 case), von Eiselsberg (1 case), Schultze (1 case), Elsberg and Beer (3 cases, 1 death), Elsberg (5 additional cases, 1 death), and several other surgeons.

The causes of death after operations for intraspinal tumors, aside from shock and hemorrhage and the undue prolongation of operations, have been purulent meningitis, respiratory paralysis in high cervical operations, and exhaustion in irremovable tumors.

Meningitis should never occur if the aseptic technic is perfect, and if the dura has been well closed at the end of the operation. Even when cerebrospinal fluid leakage occurs after the operation, the occurrence of a secondary infection can be prevented by the proper treatment of the wound when the dressings are changed. I have seen respiratory paralysis after the removal of a tumor from the upper cervical region and, therefore, advise a 2-stage operation when the tumor lies above the level of the fifth cervical segment of the cord.

INJURIES TO THE SPINE, WITH SPECIAL REFERENCE TO SPINAL FRACTURES

Within recent years it has been shown that not a few of the conditions that were formerly called "sprains of the back" are really rupture of vertebral ligaments or fractures of a spinous or transverse process of a vertebra. The many joints and bony processes surrounded and held together by strong ligaments and covered by large muscles are an explanation of the remarkable strength of the vertebral column and its resistance to injury, but this peculiar structure offers many opportunities for lesser injuries.

These comparatively slight injuries cause few symptoms besides pain and stiffness of the back, and are soon relieved by rest and simple remedies. Sometimes it is necessary to immobilize a part of the spine for a few days, and if so, simple strapping with adhesive plaster will usually suffice. The pain may be severe so that the spine has to be immobilized by means of a plaster-of-Paris jacket.

RUPTURES OF SPINAL LIGAMENTS

Ruptures of spinal ligaments usually require no special treatment, but it occasionally happens that a ligamentum subflavum is torn off from part of its attachments and makes pressure upon the spinal cord or nerve roots. In such a case, of which I have seen 2 instances, a laminectomy and removal of the torn ligament may become necessary.

FRACTURES OF THE SPINE

Fractures of the spine occur most often in the midcervical (fourth to sixth) or the lower dorsal (eleventh, twelfth dorsal, first lumbar) regions. In the cervical region the spinal canal is large and the vertebræ are freely movable upon each other. In the lower dorsal and lumbar regions the vertebræ are held together more closely by the thick ligaments, and the spinal canal is relatively narrow. As a result of these anatomical features, fractures of the cervical spine are often accompanied by considerable dislocation of the vertebræ and injury to the cord, although the vertebræ may slip back into place immediately after the trauma. In the lower dorsal and lumbar regions, however, the fracture dislocation of the fragments or vertebræ more often persists. The significance of a fracture of the spine lies more in the injury that is inflicted upon the spinal cord and nerve roots than in the fracture itself. Our remarks deal only with the treatment of the patients and with the indications for operative treatment.

Treatment of Recent Fracture of the Spine.—Great care must be taken in the transportation of these patients and their care in bed. As soon as possible, the vertebral column should be immobilized upon a large dorsal splint. If the fracture is in the cervical or upper dorsal regions, the splint, a well-padded board about 6 to 8 inches wide, should be bandaged to the patient's back, extending from the lower dorsal region to beyond the head; if the injury is below the upper dorsal level, the entire vertebral column must be immobilized by a long posterior splint. A lumbar puncture should be done at once, for it will show whether there is a large amount of blood within the spinal canal, and the removal of some fluid will relieve the pressure upon the spinal cord. An X-ray examination should be made as soon as it can be done, plates being taken to give both an anteroposterior and a lateral view.

If the patient is firmly bandaged to the long posterior splint, he can with safety be turned from one to the other side and lifted up. Catheterization of the bladder must be done at regular intervals, and urotropin given in full doses.

From the very beginning the most scrupulous care must be taken to prevent decubitus, the patient being placed upon a water or air mattress, and all bony prominences being protected against pressure by means of rubber rings and cotton pads. When the symptoms of shock are prominent, active stimulation is, of course, given.

In what patients is operative interference called for? For fractures above the fourth cervical vertebra with injury to the cord very little can be done, as the patients usually succumb within a few hours or sooner, with symptoms of medullary disturbance. For fractures at a lower level, the following rule may be adopted:

> Unless the condition of the patient is so poor that operative interference of any kind is out of the question, interference is indicated as soon as possible when we have the evidence that there is a compression of the cord by bone or blood, or when the signs point to a marked contusion of the cord.

If the cord symptoms are such as to indicate that there are still numerous pathways up and down the cord unaffected, if there is only a partial loss of power below the level of the fracture, if sensation is preserved over some areas below the level of the lesion, if some of the reflexes are preserved, and the control of the bladder and rectum not entirely lost, a laminectomy should be performed as soon as possible. If the X-ray fails to show any marked bony deformity, we may be fairly certain that the symptoms are due to a great extent to a contusion or partial crushing of the cord. On the other hand, the X-ray may show that fractured laminæ are compressing the spinal marrow or that the spinal canal has been narrowed by the prominence of a crushed body of a vertebra.

The contusion of the cord is soon followed by an edema of a very destructive nature or by bleeding into the spinal substance. The edema is very apt to cause, within a day or days, a complete and irremediable transverse lesion of the cord. Its spread can be prevented by the decompressive effect of the laminectomy.

If, on the other hand, immediately after the accident, the patient has a complete loss of motor power and sensation with loss of superficial and deep reflexes below the level of the lesion and loss of the control of the bladder and rectum, there is very surely a complete and irremediable transverse lesion of the spinal cord, and no operation should be done. Operation will only hasten the death of the patient in many instances. The disrepute into which operations for recent fracture of the spine with injury to the spinal cord have fallen is due to a great extent to the fact that patients with a transverse cord lesion have been operated upon. In a very few instances improvement has followed the operation, but in these patients there could not have been a transverse lesion in the cord.

In the patients in whom operative interference is indicated the operation should be done as soon as possible. One may wait a few hours so that symptoms of shock may be overcome, but in most instances delay is dangerous. If the patients are seen after a few days, the operation should be done without any further delay.

The spinous processes and laminæ are removed in the usual manner and the dura widely opened. Fluid blood and clots are washed out of the spinal canal by means of gentle irrigation with saline solution. The cord will usually be found more or less congested, often of a bluish color. If it is much swollen, it should be punctured with a fine aspirating needle and any small collection of blood emptied. Recently A. R. Allen, of Philadelphia, has published a very valuable experimental study demonstrating the value of incising the cord to relieve the dangerous edema. This operation has, up to the present time, been tried only a few times in the human being, but I believe that it has a future. In the section on intramedullary surgery I have shown that a small incision in the cord may be made with safety if properly done, and I think that in the proper cases it should be made in the condition under discussion.

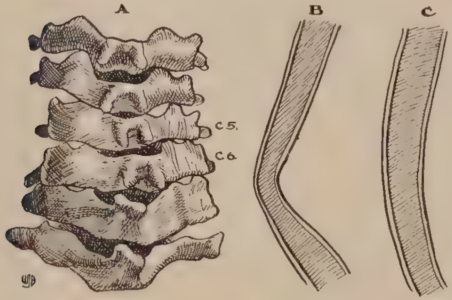

Fig. 33.—Old Fracture of Fifth and Sixth Cervical Vertebræ With Compression and Angulation of Cord. A, The deformity of the vertebræ; B, the compressed and angulated cord; C, the result of the free removal of spines and laminæ.

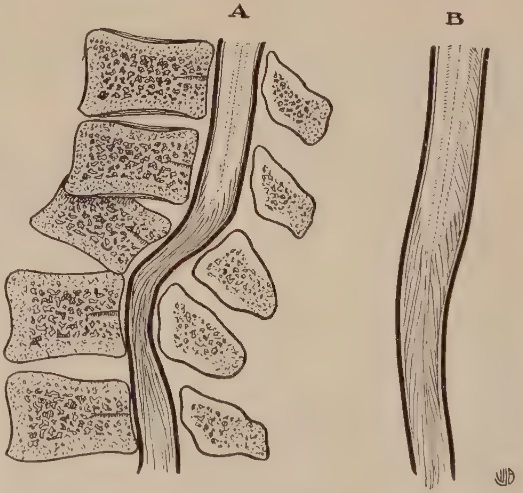

Fig. 34.—A—Compression and Angulation of Cauda Equina Due to Old Fracture of the Spine. B—The Straightening Out of the Conus and Nerves After the Laminectomy.

Operative Interference in Old Fractures of the Spine.—In the present state of medical and surgical opinion regarding the indications for operations in recent fracture with injury to the spinal cord it is inevitable that many patients are allowed to go on without surgical interference who should have been operated upon. In some patients the symptoms of cord injury were not very marked for weeks or months after the accident, but after a time signs of serious and progressive interference with the cord functions appeared. In some patients the early signs of cord injury cleared up to a certain extent, but improvement soon ceased. In many of these the X-ray examination made long after the injury shows that, due to the original injury or to new bone formation, there is a marked narrowing of the vertebral canal and, therefore, pressure on the cord, or a partial dislocation of the body or a lamina of one or more vertebræ, which has caused a decided angulation of the cord (Figs. 33 and 34). Many of these patients are incapacitated on account of well-marked paralysis of one or more extremities. By means of laminectomy, with free removal of spines and laminæ well out to the intervertebral foramina, a narrowed spinal canal can be much widened, pressure of bone upon nerve roots can be removed, and marked angulation of the cord straightened out (Figs. 33 and 34) by allowing room for the dural sac and cord to bulge backward. In some of these patients the prominence on the posterior surface of the body of a vertebra can be removed extradurally.

To accomplish this the dural sac must be carefully drawn to one side and freed from the posterior surface of the body of the vertebra. Considerable oozing from the plexus of veins usually takes place. This can usually be controlled by gauze packings. With care and patience, the posterior surface of the vertebra can be well exposed so that the offending prominence can be removed with a small chisel or with fine rongeur forceps.

The dura must always be opened, so that any adhesions between the cord and the inner surface of the dura can be divided.

Results.—The mortality after operations for fracture of the spine with injury to the spinal cord has been very large, no doubt due to the fact that many patients with a hopeless complete crush of the cord were subjected to operation. Fracture of the spine occurs most often in the cervical region, and if the injury to the cord has caused a complete transverse softening, the process is very apt to extend upward in the cord and to hasten the fatal outcome through medullary involvement. When, as is most often the case, the cord has been injured, the prognosis with or without operation is very serious. Gurlt collected 270 cases with a mortality of 80 per cent.; Burrell, 244 cases with a mortality of 64.5 per cent.

Thorburn collected 56 cases of fracture of the spine with operation, with a mortality of 67.8 per cent. Lloyd collected 185 cases; in 82 cases in which immediate operation was performed there was a mortality of 72.2 per cent.; Chipault collected 157 cases from the literature; of these 79.5 per cent. died after the operation, while 21.5 per cent. recovered or were improved. Smaller statistics show a higher death rate.

I believe that the surgeon should be extremely conservative in his indications for surgical interference in recent fracture of the spine, for if there has been a transverse crush of the cord, the operation will not benefit the patient even if he remains alive, and if he has not a transverse lesion, a short delay will not do great harm.

In fractures of the spine of months' or years' duration, the results from surgical interference are far superior to those just mentioned, and I have seen many patients enormously improved by the laminectomy.

RHIZOTOMY OR DIVISION OF THE POSTERIOR SPINAL ROOTS

This operation was originally proposed by Dana, of New York, for the relief of severe pains due to an ascending neuritis, and was first performed by Bennett, of London, in 1886, and Abbe, of New York, in 1888. Since that time the procedure has been tried in a number of conditions, and the operation has been done a great number of times.

Indications.—The indications for the division or excision of the posterior roots are the following:

1. For the relief of pain.
2. For the relief of spasticity (Foerster).
3. For the relief of the gastric crises of tabes (Foerster).

As regards the first of these indications, the following may be said: Inasmuch as the posterior nerve roots carry all sensations of pain to the spinal cord, one would have expected that in cases of intractable neuritic pain, in the so-called plexus neuralgias, in malignant disease of the vertebral column, and other painful affections, the division of the sensory roots of the cord would abolish the painful sensations. While relief was afforded in some of the patients, very little result or no result was obtained in many others. In many of them an insufficient number of roots was divided, while in others pain persisted after the division of a large number of posterior roots. Thus Frazier cites a case of brachial plexus injury in which the sense of pain was not altogether removed from the affected limb even after the division of all the roots from which the brachial plexus receives its sensory supply.

This variability in the results obtained should make the surgeon very cautious in his statements as to the amount of relief that will follow the operation.

Division of the posterior roots for spasticity was first proposed by Foerster, of Breslau, where the spasticity and spastic paralysis were due to disease of the corticospinal paths, and more especially the pyramidal tracts. Basing his observations upon the physiological nature of muscle tonus, and the pathogeny of muscle spasticity, he showed that relaxation of spasm must and did occur when the proper posterior roots were divided, when the sensory part of the reflex arc was excluded. The operation may be indicated in congenital spastic paraplegia, in spinal spastic paraplegias due to trauma, syphilis, and other similar conditions. It should never be attempted in other motor disturbances such as athetosis or torticollis. In these cases the muscular spasms are not due to an increased influx of sensory stimuli to the cord, but to an increased afflux of motor impulses from higher centers.

The operation should never be attempted unless the disease process has become stationary or is advancing very slowly. Therefore, as Foerster has pointed out, the procedure is contra-indicated in most cases of disseminated sclerosis. In spastic paralysis due to tumor, the tumor must first be removed; in Pott's disease the bone process must have reached a standstill.

Resection of the posterior roots is the only definite method we possess for the relief of the visceral and more especially the gastric crises of tabes. These crises are produced by the irritation of the sensory sympathetic fibers of the abdominal organs, which fibers run in the posterior nerve roots.

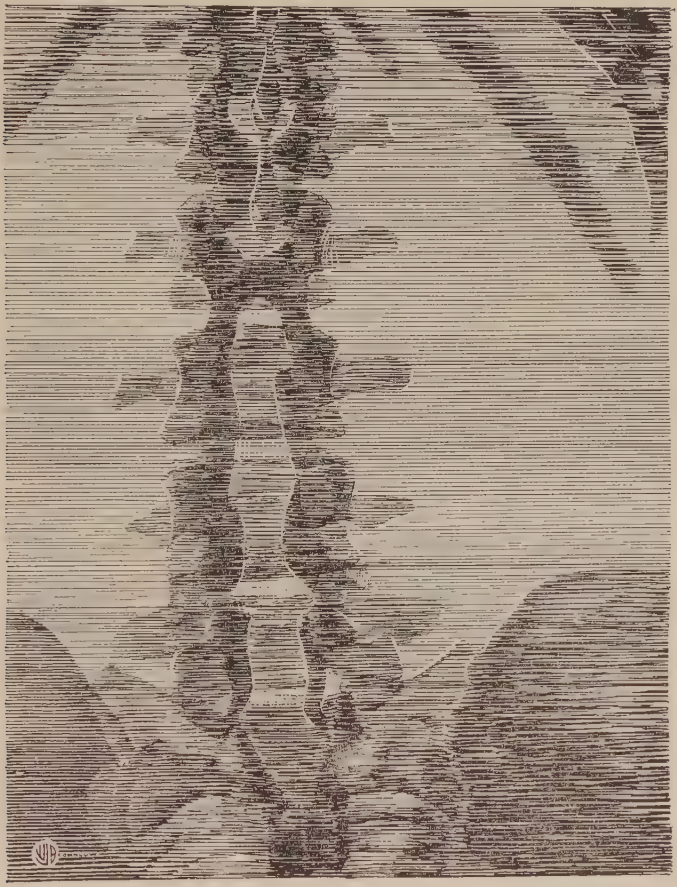

Fig. 35.—X-ray Sketch of Hiatus Left After Laminectomy in the Lower Lumbar Region.

Roots to be Divided.—In many of the patients in whom posterior spinal roots were divided for the relief of pain, spasticity, or the gastric crises of tabes no result was obtained because too few roots were divided. It is of essential importance that the surgeon shall have a thorough understanding of the areas of the skin supplied by the dorsal nerve roots and the segments of the cord with which these roots are connected. Sherrington and Grünbaum have demonstrated that the peripheral sensory areas are supplied by branches of 3 posterior roots, so that insensitiveness of the skin over such an area occurs only when 3 successive nerve roots are cut. While this is correct in most instances, cases have been reported (Clark and Taylor, Hildebrandt, Elsberg) where the division of 4 or 5 adjacent lumbar roots produced no apparent disturbance of sensibility.

It should be a general rule to divide rather too many roots than too few, and for the relief of pain always to divide a larger number of roots than the number which is known to supply the painful area. Thus Foerster has shown that the sensory supply of the arm is derived, not only from the fifth to eighth cervical and first and second dorsal, but also from the third and fourth cervical and the third dorsal. The sensory supply of the lower limb is derived from the tenth, eleventh, and twelfth thoracic as well as the lumbar and sacral roots. Therefore, in order to relieve painful affection of an extremity, a large number of roots must be divided, no matter how extensive the anesthesia which results from the operation.

When posterior roots are to be divided for the relief of a spastic condition, the roots that are cut can be so selected that no or very slight sensory disturbance follows the operation. In each patient the spastic muscles must be carefully determined, so that the proper nerve roots can be selected. According to Foerster, the following is the relation of the sensory roots to the muscles of the lower extremities:

Flexors of the thigh—L I to L V, S I.
Extensors of the thigh—L V, S I, II.
Adductors of the thigh—L II to L IV (L V).
Abductors of the thigh—L V, S I, II.
Ext. rotators of the thigh—L V, S I, II.
Int. rotators of the thigh—L III to L IV, S I, II.
Extensors of the leg—L II to L IV.
Flexors of the leg—L V, S I, II.
Dorsal flexors of the foot—L IV, V, S I.
Plantar flexors of the foot—L V, S I, II.

For a more detailed account of the sensory and motor nerve supply of the individual muscles, the reader is referred to the large tables that are to be found in most works on neurology. Foerster states that in the upper extremity it is usually necessary to divide or resect at least the fourth, fifth, and eighth, or the fifth, sixth, and eighth cervical roots, but I have had an incomplete relaxation of the upper extremity after division of the fourth, fifth, seventh, and eighth cervical and first dorsal roots. In the lower extremity it is advisable, according to Foerster, to divide the second, third, fifth lumbar and second sacral roots.

While it requires much care and good judgment not to divide too few nerve roots, it must be remembered that if too many nerve roots are divided, or nerve roots are divided that are reflexly connected with muscles that are more paralyzed than spastic, too great a relaxation of the muscles of the extremity may result.

When the posterior root section is performed for the relief of the gastric crises of tabes, a large number of roots have to be resected or divided and an extensive area of anesthesia results. Originally Foerster advised that the seventh to tenth dorsal roots should be resected on both sides; later he declared that the sixth to the twelfth was often not sufficient.

Technic.—For the intradural division of posterior nerve roots, the laminectomy is performed in the usual manner, although in some cases, where only a few roots on one side have to be cut, the unilateral laminectomy recommended by A. S. Taylor may be sufficient. If the operator knows to a certainty which spines and laminæ he has removed, he will have no difficulty in recognizing the nerve roots he is to divide.

The dura is incised and the edges retracted in the usual manner. The nerve roots are then successively raised upon a strabismus hook near their point of origin from the posterior column of the cord and divided with a fine curved iridectomy scissors. The divided root is then grasped with a fine forceps and cut near its point of exit from the dura. In this procedure, care must be taken that the anterior nerve root, which lies just in front of the posterior root near the dural opening, is not injured. Occasionally there is slight bleeding from a small vessel which runs near the upper border of each nerve root. If the vessel is very large, it must be tied with very fine silk. Usually the bleeding is inconsiderable and easily controlled by irrigation with warm saline solution. When the desired roots on one or both sides have been divided, the dura is closed by a running suture of silk, and the muscles, fascia and skin are brought together.

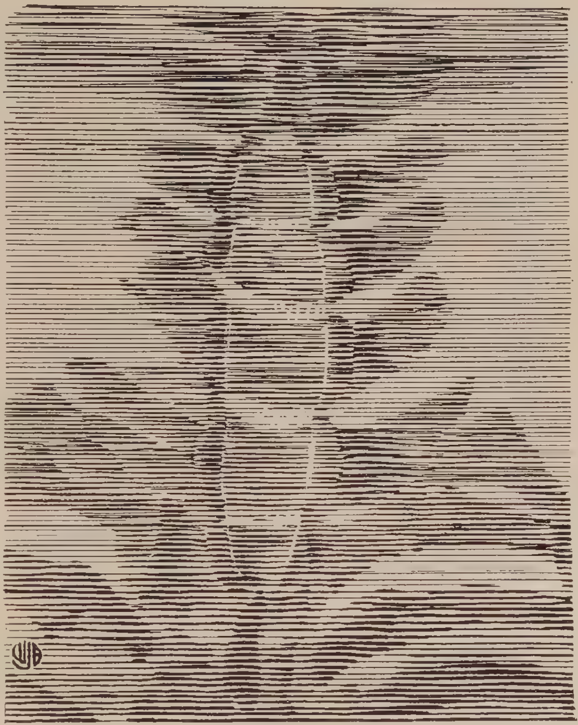

FIG. 36.—X-RAY SKETCH OF CERVICAL REGION AFTER LAMINECTOMY.

The operation can usually be completed in ½ to 1 hour. In small weak children, care must be taken that very little blood is lost and that the operation is performed in as short a time as possible.

After-treatment.—The after-treatment of patients who have had a laminectomy and division of posterior roots for a painful affection or for the gastric crises of tabes does not differ from that after a laminectomy for any other disease. When the operation has been done for a spastic condition, it is often advisable to bandage the affected extremity upon a straight splint if the relaxation is complete. After the return of voluntary mobility, a long and carefully managed after-treatment is necessary, by means of which alone the control of the muscles of the extremity or extremities is regained. Therefore, a certain amount of intelligence on the part of the patient is necessary, and cases of cerebral diplegia with idiocy are unsuitable for the operation. Massage, exercises, tenotomies, and other orthopedic treatment are usually required for many months or several years, and little permanent result can be expected unless such treatment is conscientiously carried out. This has led some critics to declare that with the same amount of treatment, most patients would show the same improvement without the posterior root section. This I believe is incorrect.

Results.—The following tables from Foerster's paper show the results from the operation of posterior root section on a large number of cases collected from the literature.

Table I

Root Section for the Relief of Pain

44 cases, 6 deaths; cervical roots, 22 cases; thoracic roots, 11 cases; lumbar and sacral roots, 11 cases.

Results: Successful, 12 cases; failures, 23 cases; results unknown, 3 cases.

Table II

Root Resection for the Relief of Gastric Crises

Total number of cases	64
Survivors	58
Successful	56
Failures	2
Deaths	6
Number showing no relapse	29
Number showing considerable improvement	18
Number showing small improvement	9

Table III

Root Resection for the Relief of Spasticity

159 cases, 14 deaths

88 cases spastic congential paraplegia, 6 deaths.
3 cases hydrocephalus, 2 deaths.
8 cases of infantile spastic paraplegia.
4 cases of traumatic spinal spastic paraplegia.
1 case of spinal tumor.

1 case of Pott's disease.
6 cases of syphilitic spinal spastic paraplegia.
11 cases of disseminated sclerosis, 4 deaths.
23 cases of spastic arm paralysis, 2 deaths.

The operative results in the hands of single surgeons show a mortality which is not as high as that shown in the tables of Foerster. Thus Kuttner had 2 deaths in 31 operations; Eiselsberg had no deaths among 12 cases; and I have performed 14 operations without fatality.

In general, the results from posterior root section for spasticity are better for the lower extremities than for the upper extremities.

Guleke's Method.—Gulcke has recently recommended the extradural division of the nerve roots. Laminectomy is performed in the usual manner, the spinal nerves exposed at their exit from the dura, the sensory separated from the motor roots, and the former then divided. Guleke claims that the extradural operation is less dangerous than the intradural procedure, that there is less danger of infection of the meninges and of injury to the cord. The method, which was suggested by Chipault more than 20 years ago, has not found favor with surgeons because of the difficulty of separating the motor from the sensory root and the danger of injury to the motor root.

Stoffel's Method.—Finally, as germane to the subject of the treatment of spasticity, mention must be made that Stoffel has reported very good results from the division of the nerves to the spastic muscles at the points where they enter the muscles. This operation is of too recent date to allow of more than its mention.

SURGICAL TREATMENT IN OTHER SPINAL CONDITIONS

Laminectomy is sometimes required in other diseases besides those we have mentioned. Thus in osteomyelitis of a vertebra with extradural abscess, I have twice had to perform a laminectomy in order to remove diseased bone and drain the abscesses. Sinuses may remain after a periarticular abscess of the spine and may require the removal of spinous processes and laminæ.

The operation may be called for in tuberculous disease of the spine, and in rare conditions such as actinomycosis (Theobald's Case), hydatid cyst (Theobald's case), blastomycosis (Brewer's case).

Of very recent date is the treatment of various other intramedullary affections, besides tumors, by operative means. In some cases of hydromyelia and syringomyelia laminectomy with incision of the cord and drainage of the fluid into the subdural space has been followed by marked amelioration of symptoms (Elsberg, Foerster).

Bailey and I have called attention to the decompressive aspects of the operation of laminectomy. Marked improvement has followed in some cases where no gross lesion could be found at operation. The results obtained are probably due to changes in the spinal circulation from the laminectomy or to the entrance of air into the spinal canal.

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CHAPTER XV

SPINA BIFIDA

Norman Sharpe

General Considerations.—Spina bifida is the most common congenital anomaly of the spine. Occurring, as it does, once in 800 births, every obstetrician will be confronted by this condition at least once, and the surgeon will have several of these unfortunate children referred to him for treatment. Naturally, the only successful treatment is a surgical procedure. Until the last few years, however, the majority of surgeons, with a few exceptions, have regarded the condition as surgically hopeless. Except in the simplest forms of spina bifida, the tendency has been to defer operation, leaving these children to an almost certain death, as over 90 per cent., if not operated upon, will die in the first year alone. According to the Committee on Spina Bifida of the London Clinical Society, of 647 deaths of children with spina bifida reported in 1 year, 612 were under 1 year of age. Even with operation, at the present time, the mortality, including those who die shortly after operation and those who die weeks or months later from associated lesions, is almost 55 per cent. While this may seem a tremendous mortality in these days of comparatively low operative death, yet as a life-saving measure the surgical treatment has an advantage of 40 per cent. over the policy of non-interference. With a better knowledge of the cause of this condition and improved surgical treatment, however, this percentage of mortality (55 per cent.) should be much lowered.

The term spina bifida is used to designate certain congenital defects in the vertebral column due, I believe, to the presence in fetal life of an abnormal amount of cerebrospinal fluid in the spinal canal. This causes a pressure which prevents the vertebral segments from closing or separates them after closure has been effected, and drives out, through this opening, some of the contents of the canal, forming a sac or protrusion. This defect and protrusion occur nearly always posteriorly, though the pressure rarely causes a defect in the bodies of the vertebræ or in the pedicles. The protrusion may extend forward into the abdomen or pelvis, the spinal arches being unaffected. There are at times, however, both an anterior and posterior defect and protrusion.

Since the report of the Committee on Spina Bifida of the London Clinical Society in 1885 (46), it has been generally taught, in accordance with the Committee's findings, that spina bifida is caused by lack of development of the laminæ of the vertebræ so that they fail to meet, the spinous processes being absent and the bony canal remaining unclosed. In the case of anterior spina bifida the theory was that the lack of development lay in the bodies of the vertebræ. It is true that the laminæ in most cases of spina bifida show only partial development. There are excellent reasons for believing, however, that this is not a primary condition, but is due to their being kept apart and prevented from functionating. An analogous condition is presented in the case of the "false" ribs, so called. The primary and inciting cause of spina bifida, as will be discussed later, is the presence in the spinal canal of an increased amount of cerebrospinal fluid in fetal life, which raises the intradural pressure to an abnormal degree, preventing the closure of the bony canal. This increased intradural pressure, acting in variable amounts during fetal life and at different stages of fetal development, produces the different types of spina bifida with which we are afterward confronted.

As to the causes of the increased amount of fluid present we are still in ignorance. The underlying factors at work are concerned with an increased activity of the choroid plexuses, or, what seems more probable, an obstruction to the normal outflow. That the amount of intradural pressure necessary to produce spina bifida may be but moderate in fetal life is shown by the fact that in the grater number of infants born with spina bifida there exists little, if any, external evidence of hydrocephalus or of other signs of intracranial pressure. That the primary inciting causes of abnormal production of cerebrospinal fluid still exists after birth, in the majority of cases, is shown by the fact that following operation for spina bifida, where the protrusion is removed and the defect closed, hydrocephalus will develop, and that the earlier these infants are operated upon, the more likely is hydrocephalus to follow. It seems as though the increased pressure, by causing a vent in the spinal column with the protrusion of a fluid-filled sac, in this manner affords relief; while the abnormal activity of the choroid plexuses ceases for the time being and sometimes permanently. That this pressure is not always moderate in amount, but may be quite severe, is shown by those cases of spina bifida in which there is a double gap in the bony canal occurring at different levels, as reported by Reineking, and by those cases of spina bifida which are associated with protrusions in the cranium, as reported by MacArtney and also by Rachford, Phillips, and others.

Etiology.—Various theories have been put forward in the past as to the causative influences at work in the production of spina bifida. The first noteworthy work in this regard was carried out by the London Clinical Society. It appointed a Committee on spina bifida which, after an exhaustive review of cases, made its report in 1885 (46). Only those cases were considered which the Committee had personally investigated, or which were correctly reported beyond a doubt. Of the whole number of cases, 125 of which were specimens from museums, the sex was reported in 156 as follows: 82 females, 74 males. Of 1,768 cases reported from all England, 989 were females and 779 were males. Demme reports in 57 cases, 31 females and 26 males. Apparently, therefore, spina bifida occurs somewhat more frequently in females.

As to the etiology the Committee reported as follows:

> "The anatomy of spina bifida assumes a primary defect of development of the mesoblast, from which the structures closing the vertebral furrow are developed. After the closure of the neural furrow it would appear that the processes of mesoblast which should insinuate themselves between the primitive spinal cord and its overlying epiblast, are formed in an insufficient degree to meet and combine. Involvement of the cord occurs in 95 per cent. of the cases. This failure in development of the mesoblast occurs before the spinal cord is segmented from the epiblast from which it is developed. Hence it remains adherent to the epiblastic covering and the structures which should be formed between the cord and skin are undeveloped."

This theory has been generally accepted until the present time.

Amniotic adhesions have been cited as the cause of spina bifida. According to this theory the traction of amniotic bands prevents the mesoblastic tissues from crossing over between the epiblast and cord, and the medullary groove remains open. This theory has been given but slight support. Dareste, Morgan and Tsuda, and others have produced spina bifida in the embryos of chicks and amphibians by chemical, mechanical, and thermal stimulation. The embryos of amphibians have no amnion.

Kyphosis of the fetal spine due to exaggerated curvature of the vertebral column has been advanced as a cause. According to Lebedeff, these abnormal curves of body and spine cause spina bifida by disturbing the development of the cord. If this were true, however, the majority of cases of spina bifida would occur in the upper dorsal and cervical regions, instead of in the lumbosacral region, where they are commonly found. Furthermore, in meningocele, spina bifida occulta, and in most cases of myelomeningocele, the cord is found fully developed. Nor does this theory explain spina bifida anterior.

A tumor in the central canal of the cord, causing pressure by its presence and preventing the coming together of the laminæ, has also been considered as a cause of spina bifida. Even if true, it could be responsible for only a small percentage of the cases.

The findings of the Committee of the London Clinical Society that spina bifida is due to *a lack of development of the laminæ* so that they fail to meet in the median line and thus cause a defect or gap in the bony canal, have, as stated above, been generally accepted until the present. That this lack of development of the laminæ and other mesoblastic tissues is not the primary cause, there is good reason to believe. A short review of the embryology of these tissues is necessary to a clear understanding of the processes involved. The spinal cord is developed exclusively from the epiblast, as is also the skin. The cord is formed by an invagination of the epiblast. The epidermis is then formed across the middle line, but remains adherent to the primitive cord until the tissues formed from the mesoblast (meninges, bone and muscle) arrange themselves around the primitive cord and push their way between the cord and epiblastic covering, thus separating the cord and skin.

The vertebræ are developed from 4 centers of ossification, 1 for each lateral half of the body and 1 for each lamina. The centers for the laminæ appear at the second month and extend backward and inward to meet and form the posterior arch of the bony canal, separating the cord and skin. This separation should be completed in the third month of fetal life.

The choroid plexus of the lateral ventricles of the brain is formed between the sixth and eighth weeks, so that the cerebrospinal space forms and contains fluid before the mesoblastic structures have entirely surrounded the cord and separated the skin and cord, which, as stated above, normally occurs in the third month. Therefore, if there is excessive secretion of cerebrospinal fluid or, what is more likely, any obstruction to its normal outflow, this increased amount of fluid will by pressure prevent at some point the closure of the bony canal, or will extrude the cord or its coverings at the point where solid closure is least advanced.

The laminæ arch over and meet in the median line to complete the closure of the bony canal, first, in the dorsal region. From this point the closure normally extends upward and downward, the cervical region closing next, and the lumbar region being last in order.

Where do the majority of spinæ bifidæ occur? According to Moore, who made a report of 385 cases—and his findings accord closely with those of other observers—the locality is distributed as follows: Lumbar region, 34 per cent.; sacral, 23 per cent.; lumbosacral, 29 per cent.; cervical, 9½ per cent.; dorsal, 4½ per cent. We see, therefore, that 1/3 of the cases of spina bifida occur in the lumbar region alone, and that in the lumbar and sacral regions combined, which regions of the bony canal are the latest in closing, 86 per cent. of all cases occur. Hence it is clearly evident that any increased pressure within the canal, before or during the time that the bony arches are being completed, will find a vent at the point unclosed or where closure is least advanced—the lumbosacral region; and that this relief of pressure will permit of closure of, or not disturb if closed, the dorsal and cervical regions. The early closure of the dorsal region also explains why the smallest number of spinæ bifidæ, only 4½ per cent., are found in this region.

If the excessive secretion or blocking of normal outflow occurs very early in fetal life, there may be entire absence of covering of brain and cord with only rudimentary development of these structures—a condition known as rachischisis, an extreme form of spina bifida. E. H. Hatton reports the case of a stillborn child of about 36 weeks with rachischisis, the bony coverings of brain and cord being absent from the vertex down to the lower lumbar region. The brain was but rudimentary and the 2 halves of the cord had not united, but the ventricles and choroid plexus were well developed, showing that secretion of cerebrospinal fluid had taken place. This full development of ventricles and choroid plexus is commonly found in rachischisis. It is an interesting fact, and one that may have a bearing on this matter of large secretion, that in many cases of hydramnios uteri the fetus is found to be affected with hemicephalus or spina bifida. Witham reports a woman in labor with hydramnios. On rupturing the membranes, 5 gallons of fluid came away. The child was stillborn, the occiput being absent and the brain and cord being exposed down to the last dorsal vertebra. The fourth ventricle was open.

Another point against the theory that the lack of development of the laminæ is the primary cause of spina bifida is that after operation on spina bifida, especially in very young children where the bulging sac is excised, thus removing pressure, the stunted laminæ may take on new growth and enlarge. Paterson reports a child of two months with meningomyelocele in the dorsolumbar region, in which he removed the sac and covered the gap with healthy skin. The child dying two months later, autopsy revealed the fact that the laminæ had grown considerably and reduced the gap to a narrow slit.

In skiagraphs of the spinal column in cases of spina bifida I have noticed that the bodies of the vertebræ in the region of the cleft are much broader than those above this region, a condition, doubtless, for which the pressure is responsible. If we teach that spina bifida is due primarily to defects in the bony canal, and that the increased amount of fluid and pressure is a secondary and resulting condition, how shall we explain those cases of spinal protrusions where there is no bony defect, but the sac is forced out through the spinal ligaments between the laminæ, as in cases reported by Macewen, Davis and others. J. P. Good demonstrated a spina bifida in the neck region of a ferret embryo, in which the vertebral bodies were in the early stages of cartilage formation. There was quite a sharp flexure at the site of the defect, and the laminæ were stunted and separated. The subarachnoid space was enlarged and there was an increased amount of fluid present, which he ascribed to the mechanical irritation of the flexure. The neck region is the most common site of these flexures and yet by far the greater number of spinæ bifidæ occur in the lumbar region, so that it is more than probable that the spina bifida was due to the increased fluid with pressure, and not the contrary.

Experiments carried out by me upon animals in the Carnegie Laboratory, New York City, show that intradural pressure will cause a bulging of the spinal meninges in an area where the bony arches are absent. Lumbar laminectomies were done upon young dogs, the dura not being opened and the muscles of the back held away from the defect by sutures so that the gap was covered only by skin. An area of the skull was removed and pressure applied to the head and maintained for several days. Autopsy showed a permanent bulging at the site of the laminectomy. It is easily conceivable that even a small amount of pressure in early fetal life will, by distention, prevent the closure of the spinal canal. Of course, it is impossible to prove by experiments such as I have described, whether the defect precedes the pressure or vice versa, but I believe from the facts I have put forward that it can safely be regarded as true that the *accumulation of fluid with consequent pressure* is the cause of the defect.

VARIETIES OF SPINA BIFIDA

Rachischisis.—Rachischisis, which may be either total or partial, is an extreme form of spina bifida and due to the same cause, that of increased intradural pressure. Rachischisis represents a condition in which the increased pressure was exerted very early in fetal life, at a time when the cord and its membranes were in a rudimentary state, in contradistinction to the other forms of spina bifida which originated when the cord was well developed.

In *total rachischisis,* the pressure was exerted at a time before the medullary groove had made an attempt at closure, so that the entire spinal canal is open, the skin, bony arches and membranes are absent, and the cord, being split open and only partially developed, the lining of the central canal of the cord and the layer of pia carrying blood-vessels are exposed. Total rachischisis is accompanied at times by anencephalus, so that from brow to coccyx there is a wide gutter-like canal, in the trough of which lies the mass of undeveloped brain and cord. This condition is usually accompanied by abnormal curvatures of the spinal column, especially in the cervical and dorsal regions.

In *partial rachischisis* only a part of the bony canal is deficient, and only a part of the cord is in a rudimentary state. The term *myelocele* is used by some writers to designate the condition of partial rachischisis. But as rachischisis, either total or partial, is incompatible with life and of little interest from a surgical point of view, it is much simpler and less confusing to use the term partial rachischisis in describing this condition of incomplete spinal fission. Total and partial rachischisis are fundamentally the same thing, only differing in degree. They are both extreme forms of spina bifida, differing from spina bifida in that in rachischisis the spinal canal is open and the cord spread out and exposed, while in spina bifida the cord is covered by skin or a membrane, and the central canal of the cord does not open externally.

Partial rachischisis is commonest in the lumbosacral region, where the laminæ are latest in closing and where the increased pressure exerts its greatest force. The open condition of the cord, with the central canal exposed and the blood-carrying layer of pia spread out, gives it a resemblance to mucous membrane or nevoid tissue, the "area medullovasculosa" of Recklinghausen. At the margin of this area is a shining membranous structure, which blends with the skin, and under the skin near the membranous junction on either side can be felt, and usually seen, the elevations caused by the ends of the rudimentary laminæ. In less severe forms of partial rachischisis the central canal of the cord opens onto the skin surface at the upper and lower poles of the defect, the intervening space being covered by a membrane composed of the blending of the endothelial lining of the central canal with the skin, accompanied by a constant leakage of cerebrospinal fluid onto the surface. MacLulich reports a typical case of this character.

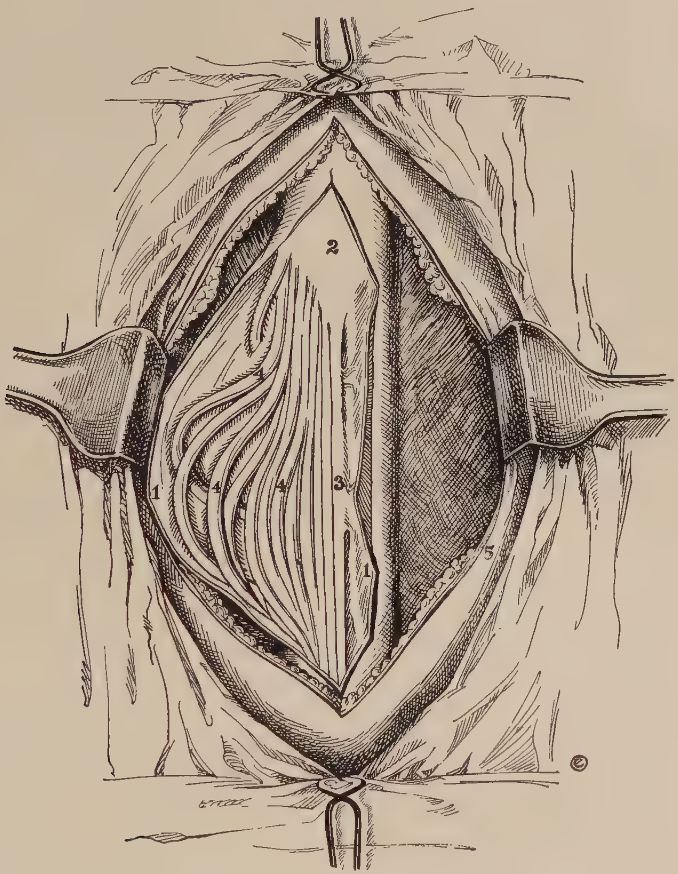

Fig. 1.—Myelomeningocele, With the Sac Opened.

Partial rachischisis is of little interest surgically, for, as stated above, it is incompatible with life, the infants living but a few days, although a child with partial rachischisis reported by Rachford lived 3 weeks.

Myelomeningocele.—Myelomeningocele is the most frequent type of spina bifida found in children who survive their birth. It is found, as variously estimated, in from 60 to 80 per cent. of all cases. It is that type of spina bifida in which the cord is fully formed, but the cord or part of it, with the nerve roots, is not lying in the spinal canal but in the sac protruding through the spinal cleft. This is due to the fact that the abnormal pressure was exerted at a time when the cord was almost completely formed, but before the mesoblastic plates in which the laminæ are developed had time to join in the median line, thus separating the cord from the skin; so that as the skin was forced outward to form the sac wall, the adherent cord and nerve roots were drawn out of the spinal canal. Commonly there is a fairly large bony defect, usually involving 2 or 3 or several vertebræ. Of course, if the cleft is low down in the lumbar region, the sac contains only the roots of the cauda equina.

Myelomeningocele is common in the lumbar region, infrequent in the dorsal, and rare in the cervical regions. These tumors are always sessile. The base of the sac is covered by normal skin, but the summit is covered by a membranous structure composed of epithelium blended with the arachnoid and pia. The dura is always absent in myelomeningocele, extending only to the membranous skin junction, and at times only to edges of the bony defect. The sac contains fluid, and the nerve elements may lie free floating in the fluid, but more commonly are attached to the posterior wall of the sac in the median line, or, just as frequently, are found spread out over the posterior wall of the sac and intimately blended with it. If the protrusion is in the upper lumbar region, at the point where the conus is adherent to the sac wall there is an inversion or dimpling of the sac wall in the median line. If the cleft is in the lower lumbar or upper sacral region, there is a broad furrow in the median line of the sac wall, marking the attachment of the cauda terminalis. If the defect is in the cervical or dorsal region, as but rarely happens, the cord quits the lower part of the sac to re-enter the spinal canal.

In myelomeningocele there are often found small nerve filaments running into the sac wall and ending there. These fibers can be safely cut without disturbing function in the lower extremities, as they are not true parts of cord or roots. They are due to the fact that in myelomeningocele the protrusion of nerve elements occurs in fetal life coincidentally with the later stages of cord development; hence these small filaments given off to the sac wall.

Encircling the area where the skin and membranous summit of the sac meet, there is a ring of connective tissue. This contains dilated plexuses of vessels, muscle fibers and at times the rudimentary and undeveloped laminæ.

The protrusion is usually unilocular, but occasionally there may be small cavities irregularly arranged and communicating with the larger sac. At times, due either to lessened intradural pressure or to traction of the adherent nerve elements, or to both factors, there is distinct inversion or umbilication of the sac, so that the whole membranous summit is depressed or cup-shaped. If the vertebral defect is narrow, the protruding nerve structures may completely block the aperture.

The membranous apex of the sac may be quite firm and strong. Usually, however, it is thin and dotted over with several ulcerating areas and moist with the cerebrospinal fluid, which sweats through. Occasionally the presence or even the attachment of the cord and roots in the sac wall is not accompanied by any disturbance of function, but more commonly the reverse is true. More or less severe paralysis of the lower extremities is present, sometimes complete paraplegia, less often sensory disturbance, often incontinence of urine, less often incontinence of feces, and very often incomplete control of vesical and anal sphincters. At times there are present the various forms of club-foot and trophic and pressure ulcers.

Syringomyelocele.—Syringomyelocele is the name given to that rare variety of spina bifida in which there is a protrusion due to the accumulation of fluid in the central canal of the cord, causing great dilatation of the cord, the pressure preventing the laminæ from closing, the dorsal portion of the cord, with the dura and arachnoid, being pushed out through the cleft. Thus, in this type of spina bifida we have a protrusion which is covered with normal skin or else has a membranous apex, and the inner lining of the sac is formed by the cord itself. The skin is separated from the sac wall (which, as just stated, is the spread-out cord itself) by the areolar tissue on the arachnoid; but very commonly the skin and sac wall are blended, due to pressure or inflammatory action. The great accumulation of fluid in the central canal of the cord causes atrophy and attenuation of the cord elements. In some cases the cord is so distended with fluid that in its dorsal portion it is reduced to a layer of pia with a few remnants of nerve elements. As it is the cord itself which forms the inner sac wall, the nerves do not traverse the fluid in the cavity of the sac, but run on the convexity of the sac to reach their foramina, covered by dura and arachnoid.

In syringomyelocele the gathering of fluid and beginning protrusion take place in fetal life after the neural canal is fully formed. This variety of spina bifida occurs usually in the lumbar region; it may be found in the cervical region, rarely elsewhere. It is a curious fact that normally, in late fetal life, the central canal of the cord becomes quite small and slit-like in the dorsal and cervical regions, but remains quite large in the lumbar region almost until birth. An excess of fluid here, with consequent pressure in early fetal life, readily accounts for the greater frequency of syringomyelocele in the lumbar region. This type of spina bifida is very rare. The Committee of the London Clinical Society, in the 125 cases of specimens from museums they investigated, found only 2 authentic cases. An illustration of the force exerted by the accumulated fluid and proof of the fact that the protrusion depends not on a cleft or defect in the bony walls of the spine, but rather on the pressure in the spinal canal, are given by a case reported by Davis in which the protrusion occurred in the lower cervical region accompanied by hydrocephalus and bulging eyeballs. The child died after operation and autopsy showed no defect in the bony arches. The sac had been pushed out through the ligaments between the arches of the seventh cervical and first dorsal vertebræ, and contained part of the posterior columns of the cord. The central canal of the cord was greatly dilated. There was no paralysis, evidence of the great pressure the cord can endure and still functionate.

Syringomyelocele is, as a rule, so translucent that in this respect it is often mistaken for meningocele, but the reason that there are no shadows cast is that the nerve elements are flattened and attenuated and do not traverse the fluid contents, but run on the outside of the sac wall, which is formed by the dilated cord.

Spinal Meningocele.—Spinal meningocele occurs in order of frequency second to myelomeningocele. Owing to the different classifications of spina bifida by various writers, it is somewhat difficult to estimate its percentage. By some writers it is regarded as very common and by others as very rare. Muscatello reports it once in 13 cases, Hildebrand found it 7 times in 30 cases, while the Committee of the London Clinical Society found it 27 times in their more than 230 cases. It has been variously reported as occurring in 8 to 12 per cent. of all forms of spina bifida. It is certainly not rare, but is not so common as myelomeningocele. In meningocele the gap or defect is usually a small one, involving but 1 or 2 of the bony arches. Several cases have been reported in which there were no defects in the vertebræ, the dura and arachnoid protruding through the intervertebral ligaments, clearly demonstrating the causative factor, that of increased and abnormal pressure.

The cleft is usually in the median line, but may be to one side, involving the laminæ of one side only. The cord and nerves occupy their normal position in the spinal canal and are not involved in the protrusion, though at times, due to pressure or irritation of the sac from without, inflammatory changes are set up, and motor and sensory disturbances occur in the lower extremities.

Spinal meningocele is situated usually in the lumbosacral or sacral regions, uncommonly in the cervical, and very rarely in the dorsal region. The sac is, as a rule, entirely lined with dura, the fluid being in the subdural space. The protrusion is often pedunculated, even when overlying a fairly wide vertebral defect. Rarely, where the sac has a slender pedicle, and there is a narrow bony defect, the opening into the canal becomes obliterated by fibrous tissue, and the tumor undergoes spontaneous cure. The protrusion is usually entirely covered by normal skin, though occasionally a small area at the summit is membranous.

Spina Bifida Occulta.—Spina bifida occulta is that form of spina bifida in which there is a cleft in the bony canal, but no protruding sac. It is the most interesting form of spina bifida from a pathological, diagnostic and surgical point of view. It represents a modification of the previously described forms of spinal bifida in which the herniated sac was originally present in fetal life, but has disappeared, owing either to lessened intradural pressure or to rupture with consequent contraction and disappearance of the tumor. That rupture of the sac with survival of the fetus does take place in intra-uterine life is shown by the fact that often a scar can be seen in the skin over the bony defect at the site of the former protrusion. Guthrie reports an interesting case of this character. The skin over the defect may be coarse, wrinkled and pigmented, or there may be a scar present as mentioned above. In about one half the cases of spina bifida occulta there is a growth of coarse black hair over the region of the defect. No satisfactory explanation of this hypertrichosis has yet been advanced. When present it is pathognomonic. It is an interesting fact that a growth of coarse, fairly long hair is present in many cases of rachischisis along the edges of the defect. At times a lipoma, dermoid, or other form of tumor occupies the cleft or the subcutaneous tissues over the cleft. If a lipoma, it may be of the ordinary variety, but is more often diffuse, noncapsulated, and spreads out over the area surrounding the defect. At times a lipoma is found in the tissues over the defect, and another in the bony cleft or even in the spinal canal, the two often connected by a fibrous band. Lipomata are as often found in connection with, and are almost as certain a sign of, spina bifida occulta as hypertrichosis. At times they are both present, the soft mass of a diffuse lipoma being felt under the area of hypertrichosis.

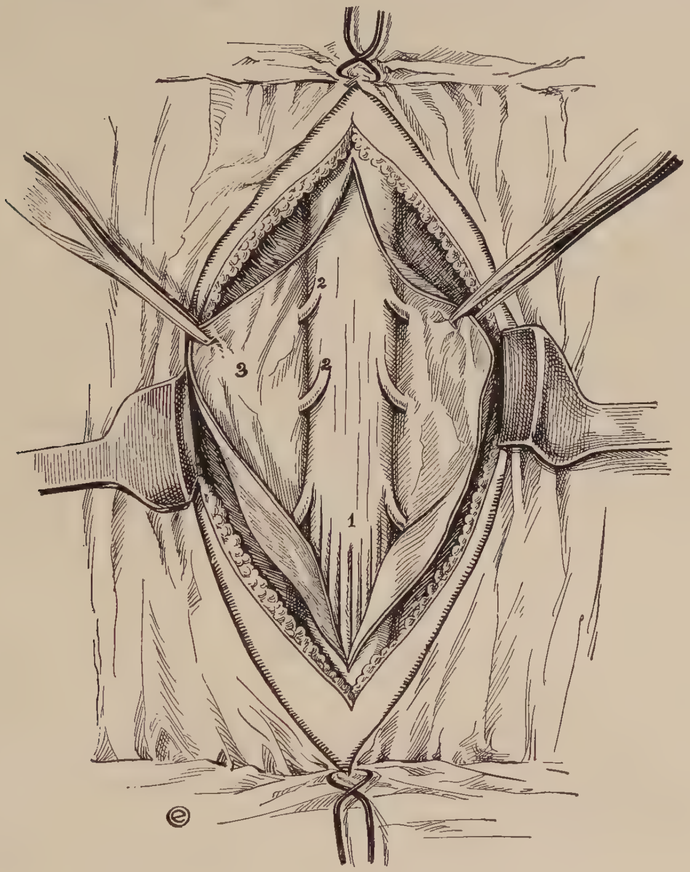

Fig. 2.—Meningocele, With the Sac Opened.

Spina bifida occulta probably occurs more frequently than the other forms of spina bifida, that is, oftener than once in 800 births. But owing to the absence of protrusion and the fact that very often there is no motor or sensory involvement, it gives rise to no disturbance and escapes notice. Thus, Brickner reports 2 cases of spina bifida occulta, in one of which there had been no disturbance of nervous function until the patient was 12 years old, while the other escaped nerve involvement until 19 years of age; nor up to this time, in either case, was a spinal defect suspected. Moore reports a woman 24 years old whose gait was that of a mild spastic paralysis and who had headache and backache. There was a heavy growth of black hair over the lumbar region. There was no protrusion, but a defect could be felt in the spine, a defect which had escaped notice for 24 years.

Spina bifida occulta is the least serious of the varieties as far as life is concerned, and gives the best prognosis with or without operation; but even where the cord and nerves are uninvolved at birth, palsies and other nerve lesions may appear as the child grows older, due to the lengthening of the spine and the ascent of the cord. The length of the spinal cord in the fourth fetal month corresponds to the length of the spinal column ending opposite the last coccygeal vertebra; but as the fetus develops, the growth in length of the cord does not equal the lengthening of the spine. At birth the cord extends only to the last lumbar vertebra, and in adult life to the upper margin of the second lumbar vertebra.

Thus, even if there is no nerve involvement at birth, as the child grows older, even to adult life, adhesions present at the site of the defect may be dragged upon by the cord as it ascends and so give rise to severe motor and sensory disturbances. Three cases of spina bifida occulta with late symptoms of paralytic and trophic changes coming on have been reported by Froelich.

In some cases of spina bifida occulta, however, the involvement of the nerve elements is present at birth and may be quite severe. A patient recently seen by me, 4 years of age, had partial paraplegia of the lower extremities and urinary incontinence present since birth. There was no growth of hair on back, but the X-rays showed a defect in the bony arches extending from the fifth lumbar to the third sacral segment, and also a defect of the left side of the sacrum. There was a diffuse lipomatous growth over the defect and extending partly over the left buttock, causing distinct thickening of this area. At operation the bony arches, as noted by the X-rays, were found to be absent, the dura was absent over the cord opposite the second and third sacral vertebræ, exposing the areolar tissue over the arachnoid. There were numerous small adhesions running down alongside the cord and roots, which were in their normal position. There is sometimes found at operation a thick, fibrous membrane closing the bony defect, perforated by bands of connective tissue, joining an external tumor with another tumor inside the canal, with compression of the cord and roots.

As stated above, spina bifida occulta is not, as a rule, accompanied at birth by nerve involvement. As a child grows older, the most common symptoms that make their appearance are incontinence of urine or feces or both, anesthesia, trophic ulcers, club-foot, paralysis of the lower extremities, and at times scoliosis, kyphosis, or lordosis.

Muscatello collected 32 cases of spina bifida occulta, of which 9 were lumbar, 8 lumbosacral, 6 sacral, and 2 dorsal.

That intradural pressure still exists in some cases, even after the sac has shrunken away, is shown by a case reported by Phillips, that of a child with spina bifida occulta with weakness of left leg, who also had a nasofrontal meningocele and some enlargement of the head.

When spina bifida occulta gives rise to nerve involvement, as it usually does sooner or later, it is a most distressing condition, and the only hope lies in prompt operation before the cord and nerves are irreparably damaged by pressure or traction. The trophic ulcers have been laid to traction of the cord, but they have appeared at the age of 2. They are probably due, as Brickner says, to lesions in the cord itself or in the ganglia on the posterior roots.

Spina Bifida Anterior.—In this rare form of spina bifida the bodies of the vertebræ are split instead of the arches, and the tumor projects anteriorly, usually into the abdomen or pelvis, rarely into the thorax. These protrusions are nearly all found in females, and almost always the defect is in the sacrum. Occasionally there is a defect in the spinal arches as well as in the bodies of the vertebræ, so that there is both an anterior and posterior protrusion. Williard reports such a case. In anterior spina bifida the tumor usually grows to enormous size, much larger than could occur posteriorly without rupture, and it is often mistaken for a common intra-abdominal growth. The pressure may split the vertebral bodies in half or rather prevent the union of the 2 halves, as the vertebral bodies develop from 2 centers of ossification, or the pressure may prevent the developing of one-half of the body of the vertebra and the protrusion is extended through the defect. Or the sac may be forced through one side at the place where the pedicles should be, or even be forced through an intervertebral foramen.

Spina bifida anterior may be accompanied by club-foot or paralysis of the legs due to irritation or traction on the anterior part of the cord. Sensory changes are less likely to be seen. Thus Robinson reported a case of anterior spina bifida in a child 11 months of age which was diagnosed as parovarian cyst. It was accompanied by club-feet and flexion of hip and knee. There was no apparent hydrocephalus, no defect posteriorly and no deformity of spine posteriorly. At the operation, a laparotomy, over a pint of fluid was drawn from the cyst and it was found to be connected with the spine. At autopsy part of the bodies of the vertebræ and the pedicles, from the twelfth dorsal to the fifth lumbar, were found to be absent. Another case very similar to the above was described in the spina bifida report of the London Clinical Society. Emmett also reported an abdominal tumor in a woman 36 years of age which was diagnosed as ovarian cyst. It was tapped through the rectum and the patient died 7 days later. Autopsy showed that the supposed ovarian cyst was an anterior spina bifida protruding from a defect in the 3 lower sacral vertebræ. There was no defect posteriorly. Cases of anterior spina bifida have been reported ranging in years from 2 months to 36 years. The case reported by Williard was a 2-months old female infant, and Bryant reported an anterior spina bifida in a woman 25 years of age in whom there had been no suspicion of a spinal defect. She died of trauma, the tumor being discovered accidentally. Kroner and Marchand reported a woman of 20 years of age with club-foot and paresis of one leg. She had a large cystic tumor in the abdomen. It was tapped and 3 liters of clear fluid were drawn off. As it refilled, it was opened and drained, and the patient died. Autopsy showed that the cyst was continuous with the spinal canal by an opening through the sacrum.

DIAGNOSIS OF SPINA BIFIDA

The diagnosis of spina bifida, with the exception of spina bifida occulta and anterior spina bifida, is, as a rule, not difficult. But to determine which one of the varieties of spina bifida is present may be very difficult; indeed, the diagnosis may not be made until the sac is opened.

Symptoms Common to All Forms.—There are several cardinal symptoms which are found in nearly all forms of spina bifida:

Presence of a congenital protrusion.
Tumor is in the median line.
Fluctuation of the mass.
Protrusion becomes tense on coughing or crying.
Summit of protrusion is membranous.
The cleft in the bone may be felt.
The tumor is translucent.

Pressure on sac causes a decrease in size with consequent bulging of the fontanel, and severe pressure may give rise to acute distress and even convulsions.

Signs of nerve involvement may be present: paralysis, club-foot, urinary incontinence and trophic ulcers.

Differentiation from Other Conditions.—Spina bifida at its most common site, the lumbosacral region, must be differentiated from the following conditions: Teratomata of the sacrococcygeal region; postrectal dermoids; lipoma; sarcoma, ischiatic hernia. Differentiation can usually be made by the fact that in spina bifida there are usually fluctuation, translucency, pressure effects, by the contour and consistency of sac, and by the fact that often there is a zone of vascularization at the juncture of skin and membranous summit.

Perhaps the most common error is made in regard to lipoma. As lipoma often overlies a small spinal defect with slight protrusion, operation to remove a supposedly simple lipoma may result disastrously for the patient.

Rachischisis.—Total or partial rachischisis offers no difficulty in diagnosis. The absent bony arches, the uncovered cord, the pinkish or red nevus-like appearance of the spread-out "area medullovasculosa," the open central canal with constant discharge of cerebrospinal fluid, all combine to present a picture which is easily recognized.

Meningomyelocele.—Meningomyelocele is most commonly found in the lumbar region, uncommonly in the dorsal and rarely in the cervical regions. It may be of small or large size, but generally has a fairly large bony cleft, which can usually be felt. This form of spina bifida is always sessile and covered at base only with normal skin. It is seldom covered on top with normal skin, but nearly always has a membranous summit which may be ulcerated, depressed or even umbilicated, depending on the amount of pressure within the canal. The apex may be ulcerated and exuding fluid. At the point of attachment of the cord there is an umbilication or dimpling of the sac wall, or a furrow, if the cord is attached for any distance. Pressure on the sac will usually cause it to decrease in size and the fontanels to bulge, but if the spinal defect is narrow, the emerging and returning nerve elements may so fill it that this sign fails.

Transillumination will usually reveal the cord, if present, as a dark shadow, or the nerves as they cross the sac to their respective foramina, but this sign is sometimes misleading because of thickening and irregularities of the sac wall. Applying a feeble faradic current to different points on the sac will often reveal the presence of nerve elements. This test can also be used after the sac has been opened and when, owing to attenuation, there is doubt whether the sac wall contains any nerve fibers. Often the diagnosis of meningomyelocele depends on the evidences of nerve involvement accompanying it. There is nearly always involvement of the lower extremities, ranging from club-foot and weakness of muscles to complete paraplegia, also sensory disturbances and defective control of the sphincters, trophic ulcers, and often hydrocephalus.

Syringomyelocele.—This may be very hard to distinguish from meningomyelocele, and at times from meningocele. It occurs most frequently in the lumbar region, occasionally in the cervical region, rarely elsewhere. Owing to the great pressure and stretching of the posterior half of the cord, this part is so attenuated and spread out over the inner wall of the sac that it may be translucent enough to resemble a meningocele. It can usually be distinguished, however, by the presence, in syringomyelocele, of paralysis of the legs and sphincters and other deformities. Also, due to dilatation of the central canal, pressure on the sac causes bulging of the fontanels more readily than in meningocele.

In the motor and sensory disturbances in the lower extremities, syringomyelocele more nearly resembles meningomyelocele, from which, indeed, it is often impossible, prior to operation, to distinguish it. It is not so frequently accompanied by dimpling or furrowing of the sac wall as is meningomyelocele, but this, too, sometimes occurs. There are, however, several conditions which are more common in syringomyelocele:

(1) The cleft is often to one side or the other of the median line.
(2) Lateral curvature of the spine.
(3) Marked kyphosis or lordosis.

Syringomyelocele is very rare, and meningomyelocele very common, so that in case of doubt, it is safe to regard the condition as one of meningomyelocele. But as the treatment for both conditions is the same, namely operation, it is not of great importance to make a positive diagnosis prior to opening the sac.

Meningocele.—Meningocele is diagnosed by the presence of a protrusion with a fairly narrow base. The sac is rarely pedunculated, though the base is narrower than in the other forms of spina bifida. The sac is translucent, and as the cord and nerve roots are not involved, there is little or no motor or sensory involvement of sphincters and lower extremities, though this does not always hold true. The sac is often covered entirely by normal skin, but there may be a small membranous area on the apex. It is difficult and at times impossible to palpate the bony defect, as there is usually only a small cleft involving but 1 or 2 vertebral arches, or there may be no bony defect, the sac being protruded between 2 arches. Meningocele is often accompanied by hydrocephalus, but this is true of the other forms of spina bifida. Pressure on the sac causes it to lessen in size, and causes bulging of the fontanels, but not so readily as in syringomyelocele. Where the defect is narrow, owing to the presence of new formed fibrous tissue in the cleft, pressure may have no effect. This closing off of the sac is common in children who have, untreated, survived their second year. In common with all spinæ bifidæ, meningocele is usually sensitive to the touch.

Spina Bifida Occulta.—Spina bifida occulta occurs usually in the lumbar, lumbosacral, or sacral regions, very rarely in the dorsal and the cervical regions. Eddington reports a rare case of spina bifida occulta involving the laminæ of the second and third cervical vertebræ, overlaid by a mass of fat adherent to the meninges, with no paralysis, no hypertrichosis and no hydrocephalus. I have also seen one in the cervical region.

Spina bifida occulta is of itself difficult to diagnose, as there is no protrusion visible and only rarely can the defect in the spine be felt. But if the examiner is alert, the associated nerve involvement will usually betray the true condition. It is for the relief of the symptoms accompanying spina bifida occulta that the patient presents himself. These symptoms may arise either in childhood, at puberty, or in young adult life. According to Brickner, coincident congenital deformities are rarely found. I have seen a child 4½ years old with spina bifida occulta who had partial paralysis and total urinary incontinence from birth.

The symptoms for which the patient seeks relief may be any or all of the following: Progressive weakness or partial paralysis of legs; incontinence of urine or feces or incomplete control of the sphincters; anesthesia; club-foot or trophic changes such as ulcers of feet, legs or buttocks. In any patient in whom the above symptoms arise at any time prior to adult life, spina bifida occulta should be suspected and search made for signs of this condition. Often the site of the prenatal protrusion on the back is marked by a scar at the point of rupture, or the skin is coarse, wrinkled and pigmented and there is present a heavy growth of hair around the area of the defect. This hypertrichosis is absent, however, in about half the cases; if found, its presence is pathognomonic. The soft mass of a diffuse lipoma may be felt, its presence, accompanied by nerve involvement in the lower extremities, being strongly indicative of spina bifida occulta. The X-rays may be of aid in the diagnosis and should always be used, though if the defect is in the median line it will often be difficult to detect it on the plate. As stated above, owing to the presence of thickened fibrous tissue in the cleft or a lipoma or other tumor, it is not often possible to feel the defect in the spine. In many patients the symptoms exist for years before the cause is recognized. Thus in a boy of 7 years, reported by Sheffield, who had suffered from cystitis with tenesmus for years, and in whom stone was suspected as the cause, the true condition of spina bifida occulta was only discovered by accident, a small protrusion appearing on the back as he was straining at stool. Moore reported a woman of 24 years of age who had had a mild spastic paralysis of the legs for years. Examination revealed a heavy growth of black hair in the lumbar region and a small spinal defect. The patient I saw had a spina bifida occulta in the cervicodorsal region. No hypertrichosis or lipoma was present. He had slight tingling and numbness of the hands when the arms were loosely hanging.

In summing up the diagnosis of spina bifida occulta, we would say that in all cases with symptoms of nerve involvement of the lower extremities, incontinence of urine or feces, club-foot, anesthesia or trophic changes, especially coming on about puberty or young adult life without evident cause, spina bifida occulta should be suspected, and thorough examination should be made of the back, especially as regards hypertrichosis, presence of tumor—particularly lipoma, and the X-ray should be used.

Spina Bifida Anterior.—Spina bifida anterior, which is fortunately very rare, may be very difficult of diagnosis unless accompanied by deformities or other signs of involvement of the lower extremities. But few of these cases have been reported as correctly diagnosed prior to operation, and some of them only at autopsy. The patient reported by Emmett (page 735), a woman of 36 who had an abdominal tumor diagnosed as ovarian, had no accompanying deformities or signs of involvement of the cord. When, however, the abdominal or pelvic tumor is associated with partial or complete paralysis, club-foot, anesthesia or incontinence, the diagnosis is not so difficult. In the case reported by Robinson (page 735), that of an 11-months infant with an abdominal tumor, the associated symptoms of club-foot and flexor contraction of hip and knee should have given rise to a suspicion of the true condition. When with an abdominal or pelvic tumor there is also a dorsal spina bifida with protrusion, the diagnosis is not hard. Thus, in Williard's case, which had a large cystic tumor in the right half of the abdomen, at first thought to be sarcoma, the presence of a spinal protrusion on the back and the fact that the child did not use its legs did lead to a correct diagnosis. Pressure on the sac of an anterior spina bifida does not often give rise to bulging of the fontanels, probably because it is difficult to exert pressure on all sides of the sac and force any great quantity of the fluid back into the spinal canal. Fairbairn reports a case well illustrating the difficulties of diagnosis, a girl of 18 with severe attacks of abdominal pain and painful micturition, which she had had at times since the age of 13. Examination showed a large, tender swelling behind the right vaginal wall, extending also to the right of the rectum. A diagnosis of cyst in the pelvic connective tissue or postrectal dermoid was made. When the cyst was opened a pint of fluid escaped and it was found connected with the sacrum. Death occurred 2 months later from meningitis, and autopsy showed the cyst connected with the spinal canal by an opening through the sacrum. These cases show that in the diagnosis of any case of an abdominal or pelvic tumor, especially in a child, the possibility of its being an anterior spina bifida should be kept in mind. Especially is this so if there be present either club-foot or paralysis of legs. Trophic changes —such as discoloration or coldness of feet and legs—ulcers, or incontinence of urine are less likely to be seen, as the majority of anterior protrusions are pure meningoceles, the disturbance of function being confined to the anterior part of the cord and due either to pressure or irritation, although if the protrusion escapes through the intervertebral foramina, the sensory changes above enumerated may be met with. The associated symptoms of spina bifida, hydrocephalus, and change in tension of fontanels on pressure on the tumor may sometimes be seen. When the defect is in the sacrum, its usual site, examination per rectum may reveal the bony defect. But in most cases of spina bifida anterior we must depend for diagnosis on associated conditions such as cord involvement or dorsal protrusions, and if these are absent, a positive diagnosis may be impossible.

PROGNOSIS OF SPINA BIFIDA

The prognosis in spina bifida, if untreated, is absolutely bad, over 90 per cent. of children afflicted with this condition dying in the first year. Here and there is a report of a child growing to adult life with a small spina bifida, one that has progressively shrunken since birth or remained stationary in size owing to occlusion of the cleft, and there are even reports, in a few instances, of rupture of the sac with spontaneous cure; but such cases are indeed rare. Demme reports that out of 31 patients not operated upon, all died in the first year and 25 died in the first month. The Committee of the London Clinical Society collected from the hundreds they investigated 13 cases of spontaneous cure. Occasionally, even if untreated, and in the presence of even a large protrusion and involvement of the cord with various motor and sensory symptoms, cases have been known to reach adult life. Greenberg reports a girl of 16 with a congenital protrusion in the lumbar region the size of a cocoanut, vesical and rectal incontinence, deformed feet and trophic ulcerations of buttocks, the latter having existed since she was 7 years of age. There was no motor paralysis and the girl had walked since she was a year old. According to Treves, persons with spina bifida have lived to be 37, 43 and 50 years of age. Taylor reports seeing a man 33 years old with sacral spina bifida, trophic ulcerations of feet, club-feet, urinary incontinence all his life, skin of legs cold and cyanotic, no paralysis, and no sexual trouble. A blow over the protrusion would cause convulsions of legs. There had been no operation. However, the few recorded cases of spontaneous cure or of the compatibility of life with a persisting protrusion do not in any way alter the prognosis, that without treatment the future of these children is absolutely dark.

Rachischisis.—Total, and even partial rachischisis are of little interest surgically, as the infant is usually stillborn or at best lives but a few days. Rachford reported an infant which had partial rachischisis extending from the sixth dorsal vertebra to the sacrum, accompanied by a hydrocephalocele in the occipital region the size of the child's head, this mass containing the elongated occipital lobes and the cerebellum. The child's temperature under artificial heat ranged from 92° F. to 107° F., yet the child lived 3 weeks. Small reports a new-born child with partial rachischisis in the lumbosacral region, the gap being 2½ in. long and exposing the cord for 1 in. He covered the gap with a pad, granulations formed shutting off the leakage of the cerebrospinal fluid and the child recovered, but developed hydrocephalus 5 months later. These are rare exceptions, however, the vast majority of cases living, at most, but a few days.

In the other forms of spina bifida the prognosis depends on several factors:

(1) The type of spina bifida present.

(2) The condition of the protrusion, whether covered with normal skin or ulcerated.

(3) Presence or absence of hydrocephalus.

(4) Amount of involvement of cord and nerve roots.

(5) The age and general condition of the child.

(6) Presence of complications, as enteritis.

If the protrusion be but small, covered with normal skin and there be no paralysis nor incontinence nor hydrocephalus, the prognosis is relatively favorable even without operation, for as the child grows older, the fluid tends to disappear and the sac to shrink. But even in these simple cases of spina bifida, free from cord involvement in infancy, as the child grows older and the cord ascends, between the ninth and the seventeenth years, motor and sensory disturbances may develop. This late involvement of the cord or nerve roots is more common in spina bifida occulta, Brickner reporting 2 and Froelich 3 cases of this character, but it has also been seen in simple meningocele.

Myelomeningocele.—Myelomeningocele, presenting, as it does nearly always, a thin membranous summit of the sac which often contains areas of ulceration, if not operated upon, will sooner or later rupture with consequent infection, septic meningitis and death as the result. Even with operation the prognosis as to complete recovery of function is less favorable in this condition than in some of the remaining forms of spina bifida, both on account of the involvement of the cord or nerve roots or both, which firmly adhere to the summit and sides of the sac, often being intimately blended with it, and on account of the fairly wide gap in the bony canal. But even so, the results from operations in myelomeningocele are vastly superior to those obtained by non-interference. Untreated, there is no recorded case of a child growing up with myelomeningocele, and very few reach the age of 5, while with operation there have been many cases of cure reported, most of them in very young infants.

Syringomyelocele.—In syringomyelocele, which is fortunately rare, the Committee of the London Clinical Society having found only 2 authentic cases, the prognosis for recovery of function, even with operation, is not as good as in the remaining forms of spina bifida. In the majority of cases the wide dilatation and tension of the central canal have so thinned the cord, especially its posterior half, and this part of the cord is so spread out and intimately blended with the sac of which it forms the inner lining, that dissection of the nerve fibers is well-nigh impossible, and to replace the nerve fibers with the entire sac in the bony canal is often a matter of great difficulty. Stoney reports syringomyelocele in a child of 5 months, with complete paralysis of the legs, the protrusion involving the lower dorsal and upper lumbar regions. At operation only a small amount of nerve tissue was found, on the sides of the sac wall. Operation effected no change in paralysis. In some cases, however, this extreme thinning of the cord elements and its blending with the sac are not present to such a marked degree, and much improvement and even cure may follow the operation. Davis reports a case of syringomyelocele in the lower cervical region, size of a half lemon, in which the pressure within the central canal of the cord had forced the posterior column of the cord out through the ligaments between the seventh cervical and first dorsal vertebræ, there being no defect in the bony arches. The protruded portion of cord was attached to the lower margin of the sac, the point of attachment being marked by a dimple. There was moderate hydrocephalus and no paralysis. Unfortunately, at the operation the portion of cord protruding was amputated, and the child died. Otherwise the operation would probably have been successful.

Spinal Meningocele.—In spinal meningocele, if untreated, the prognosis is nearly as bad as in the other forms of spina bifida, as it almost invariably increases in size, ulcerates and ruptures, followed by septic meningitis, although here and there cases of spontaneous rupture and cure are reported. Knox reports a child of 2 weeks with a meningocele in the lumbosacral region the size of an orange, which ruptured, and was followed by inflammation of the sac and spontaneous cure. With operation the prognosis is good, as the operation is relatively safe and simple, and even though the closure of the defect is often followed by hydrocephalus this usually subsides after a time, and if it does not, is often amenable to treatment. In pure meningocele, of course, the cord and nerve roots are not involved, but if there has been any disturbance of function due to pressure or irritation of the cord at the point of defect, this is relieved by operation.

An ulcerated condition of the sac may be present at birth due to great pressure from within or to the blending of dura and skin, or the sac may be so large and the tension so great that it ruptures at birth, this occurrence being soon followed by the death of the infant. Cases of this sort, however—that is, rupture during delivery—immediately operated on, have recovered, as reported by Thorndike, Nicoll, and also by Sharpe. White reports a remarkable case of meningocele in a woman aged 27, who had a congenital protrusion over the sacrum the size of a child's head, which had never given any nerve trouble. The sac began to give way, and at operation a bony defect in the sacrum 3 in. long was found.

Spina Bifida Occulta.—Spina bifida occulta is, as far as life is concerned, the least serious of the varieties of spina bifida, and usually gives the best prognosis as to life, whether treated or untreated. Representing, as it does, that form of spina bifida in which, in fetal life, the sac either ruptured, thus relieving the pressure from within, and then healed with a scar remaining to mark the site of the defect, or in which the pressure subsided without rupture, it is least likely of all the varieties to be followed by hydrocephalus. At times, however, the involvement of cord and roots in fetal life has been so severe that the child at birth is paraplegic and has urinary incontinence. The prognosis is then not so good for restoration of function by operation. In those cases of spina bifida occulta in which the symptoms of cord involvement only come on some time after birth (it may be years), and in which the symptoms are due to pressure, growth of lipoma, dermoid or other forms of tumor in the cleft, pressing down upon the cord, or due to adhesions of the roots, which in themselves may not be sufficient to give rise to trouble, but which, with the ascent of the cord, drag upon the nerve roots, operation gives good promise of relief. If, as has been found, the cause of symptoms is a fibrous band of connective tissue which joins the skin and lower end of cord and represents an imperfect separation of the two in fetal life, operation will often yield brilliant results. Jones reports a case in which he divided such a fibrous band which bound down the cauda equina. The patient had club-foot and areas of anesthesia and hyperesthesia, together with incomplete control of vesical and rectal sphincters. Six months later the patient had made an almost complete recovery. A case of Brickner's, in which at operation the meninges were found adherent to a lipoma overlying the defect, also showed marked improvement.

Anterior Spina Bifida.—In anterior spina bifida, which is very rare, Nieberding in 1904 being able to collect but 9 cases, the prognosis is bad, as all the cases reported to the present time which have been operated upon died, with the exception of 1 case reported by Grossmann, and that an atypical one. A male infant of 10 months had a swelling the size of a hen's egg in the right gluteal region, which had increased in size since birth, together with disturbances of bladder and rectum. Operation disclosed a pedicle running down to an opening on the anterior surface of the sacrum. Examination per rectum showed a defect in the 3 lower sacral vertebræ. The child recovered.

The diagnosis in the reported cases was only made during operation, and nothing much could be done. It is difficult to see how the protrusion could be removed and the cleft so closed that there would be no leakage or recurrence.

TREATMENT OF SPINA BIFIDA

Prior to the days of asepsis, the attitude of surgeons generally was one of helplessness in regard to spina bifida, with here and there a rare case reported of operation with improvement or even cure.

NON-OPERATIVE TREATMENT

Injection of the Sac.—In the early '70's there sprang into favor injection of the sac with irritating fluids for the purpose of causing inflammatory thickening with consequent shrinkage of the sac. In 1877 James Morton published an account of cases he had treated by injection of the sac with a fluid composed of iodin gr. x, potassium iodid gr. xxx, glycerin ℥ i. If the first injection was not successful, he repeated it at intervals of 7 to 12 days. Although he treated only the most favorable cases, the success he attained with injection led others to follow, and Morton's fluid became widely used. In 1885 the Committee on Spina Bifida of the London Clinical Society investigated his method, and though they found a mortality of 38 per cent. even in selected cases, yet they recommended it as the best method of treatment. Nevertheless, the use of Morton's fluid has deservedly fallen into disfavor because the method is unsurgical, in that: The diagnosis in many cases cannot positively exclude the presence of nerve elements in the sac; the injection can do possible good only in simple meningoceles, and only when the opening into the spinal canal is occluded or very small—the danger still remaining that some of the fluid may find its way into the canal and set up inflammatory changes, possibly meningitis; finally, the results obtained by open operation are superior, as shown by Mayo Robson, Nicoll, Bingham, Lovett and a host of others. If injections are made into a sac containing cord or nerve roots, even if shrinking of the sac follows, the only possible result is further compression and atrophy of the nerve elements.

Aspiration.—Aspiration of the sac or aspiration followed by pressure pads, acupuncture, ligation of the base of the protrusion, the use of setons, have all been long abandoned as useless. They failed to cure, and in many cases hastened rupture of the sac. Reineking reports a meningocele in a child 7 weeks old which was tapped 27 times at intervals of 48 hours, 4 to 10 ounces being drawn off at each tapping. After the twenty-seventh aspiration meningitis developed and the child died. This shows not only the futility of aspiration, but also demonstrates the great secreting power of the choroid plexus, although it has been shown that in excessive secretion the fluid largely loses the characteristics of cerebrospinal fluid and resembles that of an ordinary serous exudation.

OPERATIVE TREATMENT

General Considerations.—For the last 20 years, open operation with excision of the sac has been the method of choice, giving better results, being applicable to all forms of spina bifida and much less dangerous than the injection of irritating fluids. Nearly all surgeons are agreed as to the propriety of operating in these cases, the points on which they differ being the age at which the operations should be performed and the varieties of spina bifida which are proper for operation and those which should be left alone. Rose and Carless still assert that the majority of spina bifida are best left alone, the protrusion being merely guarded from injury; if signs of impending rupture appear, they advise the use of acupuncture or the injection of Morton's fluid. This view seems strange coming from such eminent authorities. Most surgeons advise operation, but until the last few years have strictly limited the operation to the simpler forms of spina bifida. Thus Mayo Robson in 1895 published a report of 20 selected cases on which he had operated. He says that a plastic operation not only gives better results than injection, but is safer. He reported a death on the table from shock with the use of Morton's fluid. Of his 20 cases which were carefully selected, ranging in age from 6 days to 35 years, 13 were meningoceles, 5 myelomeningoceles and 1 syringomyelocele. He had 5 deaths.

Where the cord or nerve roots were found tightly adherent to or blended with the sac wall, Robson advised trimming away the portions of sac wall not carrying nerve elements and placing the remainder in the spinal canal, a procedure which is now followed. He advises operation in all cases except where there is a large fissure, hydrocephalus or paraplegia. Bayer in 1897 reported 17 operations with 9 deaths, and stated that 59 per cent. of all cases operated upon would die, and that operation should not be performed when there is hydrocephalus, paralysis, or when complications are expected in the sac. He considers that spina bifida is analogous to inguinal hernia and points out that the danger of meningitis following excision is no greater than that of peritonitis following operation for hernia. He also put forth the statement that operation for spina bifida is safer and more certain of success than that for hernia, an opinion with which I cannot agree.

Nicoll was the first to urge operation in all cases. In 1898 he reported a series of 32 cases, of which 7 died within 1 month after operation, but he reported greater success than had been obtained previously. He says that a moderate degree of hydrocephalus is no bar to success, but even he excluded from operation a high degree of hydrocephalus and a sloughing sac. In no case did he find it necessary to use bone flaps.

James Moore in 1905 published an exhaustive study of 385 cases of excision which he had collected from the Surgeon-General's Office in Washington. He makes the following statements: "Prognosis without operation is hopeless, and with operation results are not very good." "In those operated upon in the first months of life the mortality was over 35 per cent. Operations after 5 years had a mortality of 4.7 per cent." He therefore advises waiting until the child is several years old, on account of the low mortality following operations after 5 years. But as over 90 per cent. die in the first year if not treated, this policy would not save many lives. Further it should be taken into consideration that Moore's deductions were made from cases reported from all over the world, from the year 1813 to 1905 inclusive, thus including the preaseptic days.

To close the bony defect some surgeons used celluloid plates; others swung over bone flaps, chiseled from the crest of the ilium; others transplanted bone from the tibia or bent down the spinous processes of the sound vertebræ above the defect. Bone flaps and foreign materials are no longer used. They added to the gravity of the operation, often failed to live in the new position, sometimes were a menace by reason of added compression, and, as we now know, are not necessary, as the fascia and muscles of the back afford strong and efficient covering.

Of late years, realizing the hopelessness of the condition of the untreated, surgeons have come to believe in the propriety of operating on all cases, irrespective of age and the condition of the sac, the only contra-indication to operation being a bony defect so great that it could not possibly be covered. It is wiser to defer operations in very young babies unless rupture of the sac occurs or is imminent. The mortality is high, to be sure, but many patients have been saved who otherwise would have succumbed if left untreated. Many surgeons have achieved good results.

Lovett reports 24 cases of excision with 9 deaths, a mortality of 37½ per cent., a percentage which would be higher had the cases been reported later. He sets the mortality following operation at 25 per cent., the mortality in the next 3 years at 25 per cent., and places the percentage of final cures at less than 50 per cent. Taking into consideration the serious nature of the condition, and contrasting the surgical mortality of 50 per cent. with the mortality of 90 per cent. in the first year alone in untreated cases, it is readily seen that the need of surgical intervention is imperative.

With a constantly improving surgical technic, the adoption of simpler methods in operating, abandonment of use of bone flaps or of foreign material to close the defect, it being recognized that they are not necessary, and better after-treatment, this mortality of 50 per cent. should be much lowered.

Causes of Death.—Very few of these children die at the time of operation. They usually withstand the operation itself remarkably well, and shock is a negligible factor unless the operation is unduly prolonged. Death following operation usually ensues from some one of the following causes:

Meningitis, due to infection.
Bronchitis, following anesthesia or due to lowered vitality.
Enteritis, which many have prior to operation, and due to lowered vitality.
The continual leakage of cerebrospinal fluid.
A remote cause of death is hydrocephalus, with convulsions.

Essential Points in Operative Treatment.—The following points are of especial importance in the successful operative treatment of these cases:

The strictest asepsis.

Maintenance of bodily heat.

Simplicity and reasonable rapidity of operation.

Tight and efficient closure of sac, muscles and fascia to prevent leakage of cerebrospinal fluid.

The most careful after-treatment to prevent contamination of wound by urine or feces.

As so much depends on the child's digestion, especial attention should be directed to this prior to operation. Children that are at the breast should not be changed to the bottle after operation if it is possible to avoid it.

Preparation of Patient.—The day before operation any noticeable growth of hair around the protrusion should be removed by shaving, the sac and surrounding area should be scrubbed with soap and water as thoroughly as the condition of the sac will permit, and a soap poultice applied (gauze thoroughly moistened with tincture of green soap). When the child is placed on the operating table, it should be well surrounded by hot water bottles and the protrusion and surrounding area again well cleansed by soap and water, followed by alcohol. It is well to avoid the use of stronger antiseptics or caustics, such as carbolic acid. When pure, this may devitalize the tissues and when used in a dilute form, through absorption, has given rise to alarming symptoms, as reported by Nicoll and others.

Technic of Operation.—The operative field having been cleansed, a straight line of incision, from the upper to the lower pole of the sac, in the median line, is lightly marked with the knife. Towels wrung out in bichlorid solution are then so placed as to closely approximate the edges of the incision and secured by pinch forceps at the membranous-skin junction. The incision is deepened and the sac is opened at a point that appears to be free from nerve elements, and from this point the sac is widely opened. Many surgeons prefer to make elliptical incisions at the membranous-skin junction, dissecting the sac free down to the margin of the bony cleft, and to open the sac at the side. This dissection is often very difficult to do and consumes much time, and there is a greater loss of blood than these children can well afford. Also, if the protrusion is entirely covered with normal skin, elliptical incisions remove tissue that can well be utilized in closure.

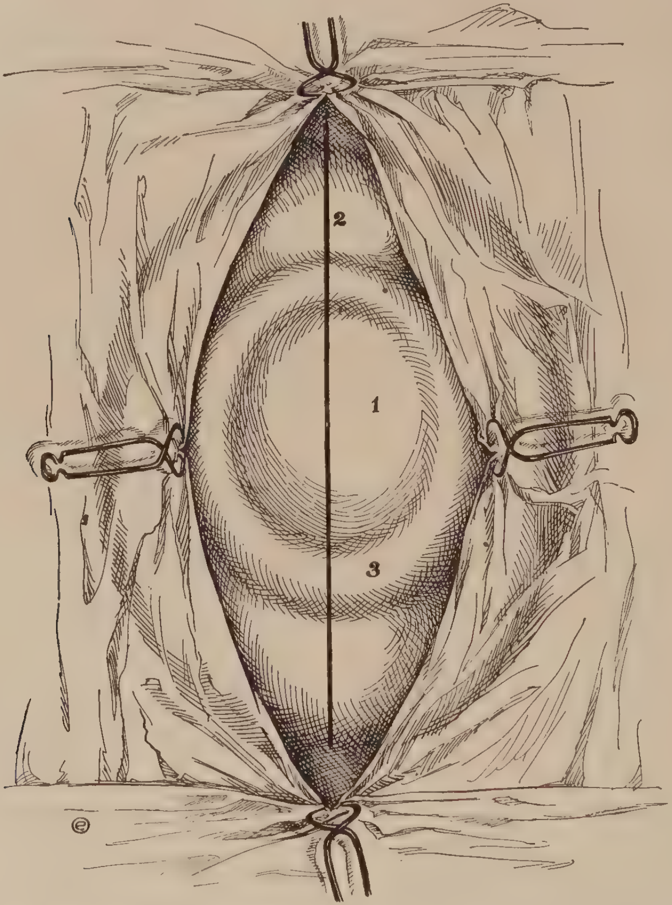

FIG. 3.—FIELD OF OPERATION. (1) Depressed area of sac; (2) line of incision; (3) membranous-skin junction.

If much fluid escapes when the sac is opened, the child's head is lowered, which immediately checks the flow. The practice, which some follow, of packing the spinal canal with gauze to prevent the escape of cerebrospinal fluid, is a dangerous one. It may cause hemorrhage within the cord and irreparably damage it. To prevent escape of fluid, Babcock operates with the child suspended by the hips over a blanket tightly stretched between the upright leg-holders of the operating table. Experience has shown, however, that merely keeping the head low is all that is necessary to prevent escape of fluid.

Careful search is made for nerve elements in the sac. If none are found, it being a meningocele, the sac wall (the dura) is stripped free at the cleft margin and closed by a double row of chromic catgut sutures, and the excess sac wall cut away.

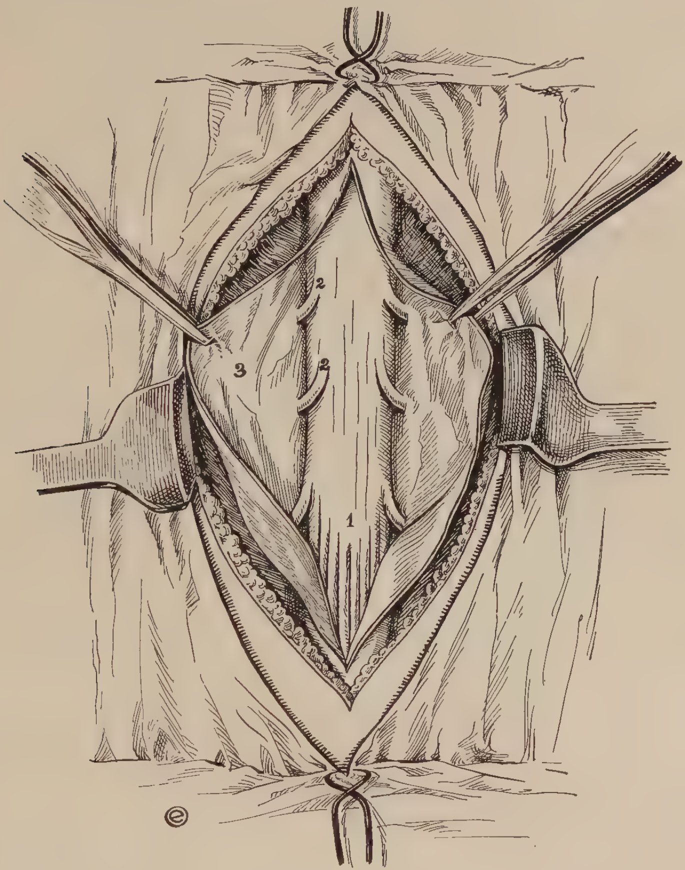

Fig. 4.—Opened Sac of Meningocele. (1) Conus medullaris; (2) posterior nerve roots; (3) dura, forming sac wall

If the cord or nerve roots are found adherent to or blended with the sac wall, a myelomeningocele, they are carefully dissected free and returned to the spinal canal. If this dissection is at all difficult, it is better, as Robson advises, to carefully separate the sac wall from the overlying tissues, trim away the portions of sac not carrying nerve elements, and return the remainder to the spinal canal. As the attachment of cord or roots is in the median line, there may be enough of the sac wall (dura or thickened arachnoid) on each side to cover over the cleft, and it is drawn together by a double superimposed row of silk sutures to prevent leakage. Or one edge is drawn under the other and secured by mattress sutures, as in the Mayo operation for umbilical hernia. Often, however, the dura extends only to the margins of the cleft, and in these cases the canal remains open until the overlying tissues are brought over. The same procedure is carried out in case the protrusion proves to be a syringomyelocele, the sac, which is the distended posterior half of the cord itself, being opened and the attenuated nerve elements returned to the spinal canal.

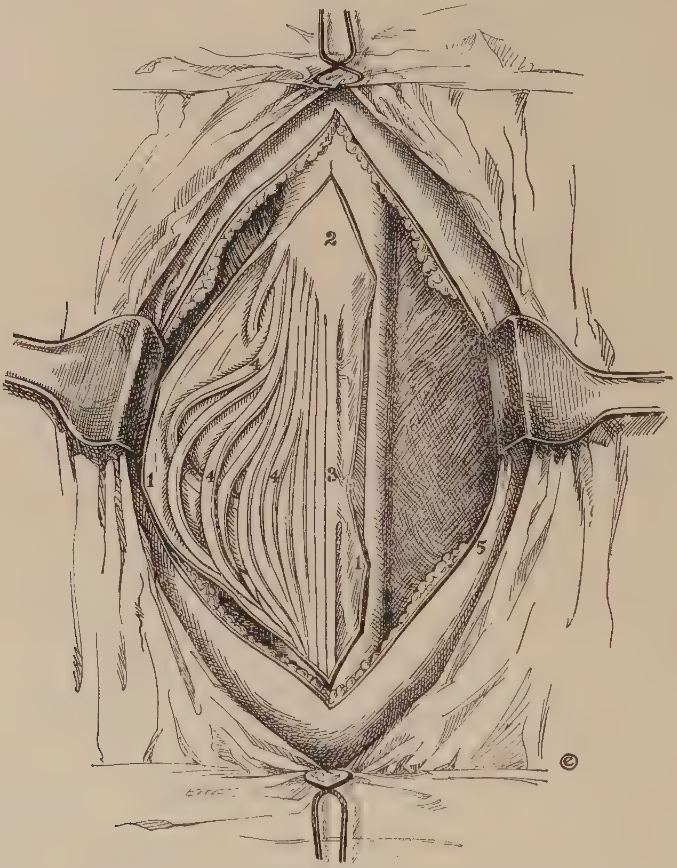

Fig. 5.—Opened Sac of Myelomeningocele. (1) Inner sac wall; (2) conus medullaris; (3) cauda terminalis adherent to sac wall; (4) roots of cauda; (5) membranous-skin junction.

Following this, a wide strip of the vertebral aponeurosis with some muscular tissue is dissected up on each side of the cleft, the strips being somewhat longer than the cleft. These are turned over to the median line, bulked there in mass and secured, without tension if possible, by 2 rows of sutures; the ends are also sutured. The membranous portion of the outer sac wall is cut away, as much as possible being left of the normal skin. To close the wound without tension is the main point, and if the skin flaps are scanty, it may be necessary to dissect them free for a considerable distance from the median line. Raw surface is sutured to raw surface with a double row of chromic catgut. This method leaves an unsightly pucker, but it obviates leakage and infection and smoothes over as healing takes place. The skin edges are closed by interrupted sutures of fine silk and a light dry dressing is applied and held in place by broad strips of adhesive plaster. Bulky dressings should not be used, as they are difficult to retain in position, are apt to slip, do not show soiling as readily as a light dressing, and are, therefore, likely to be changed less frequently than is necessary. Covering the dressing with rubber tissue and sealing the edges with collodion, or sealing the wound with gauze or cotton and collodion, is not to be recommended, as it gives a false sense of security. It does not prevent soiling of dressing, and the retained wound fluids form an excellent culture medium. Careful, frequent changing of a light dressing is the best means of preventing wound infection. The dressing should be changed each day, or oftener if contaminated by urine or feces, the wound

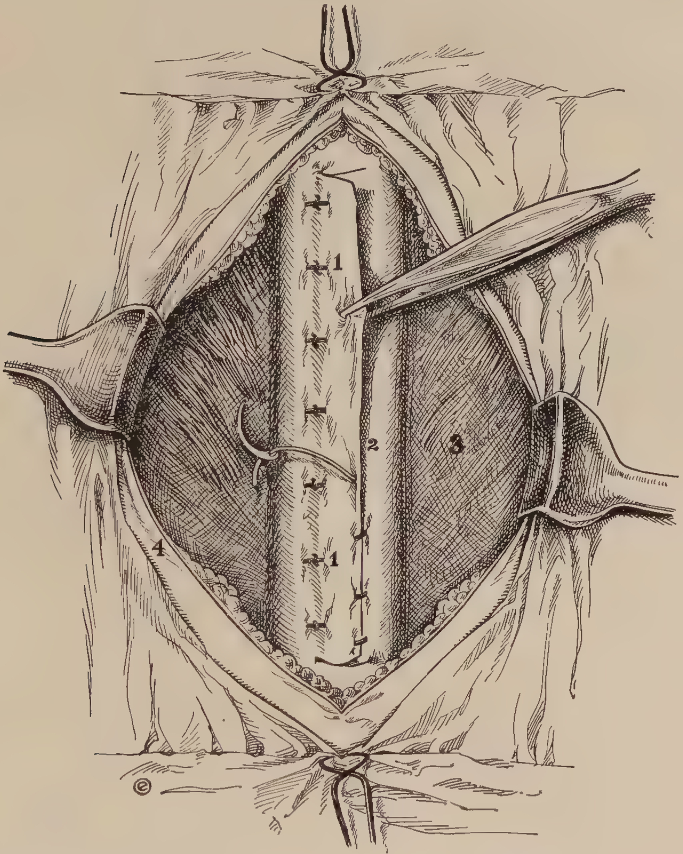

Fig. 6.—Closure of Inner Sac. (1) Mattress sutures; (2) overlapped edge of sac; (3) vertebral aponeurosis; (4) membranous-skin junction.

brushed by an alcohol sponge, and a light drying powder applied, such as aristol.

After-treatment.—It is highly important that the child be kept constantly on the face or side and closely watched to prevent soiling of the dressing. The wound should receive the closest attention until union takes place. Soiling of dressing may mean infection, and although this infection can usually be restricted to the upper layers of the wound, and sometimes to a single stitch, yet it has been known to penetrate deeper, giving rise to meningitis.

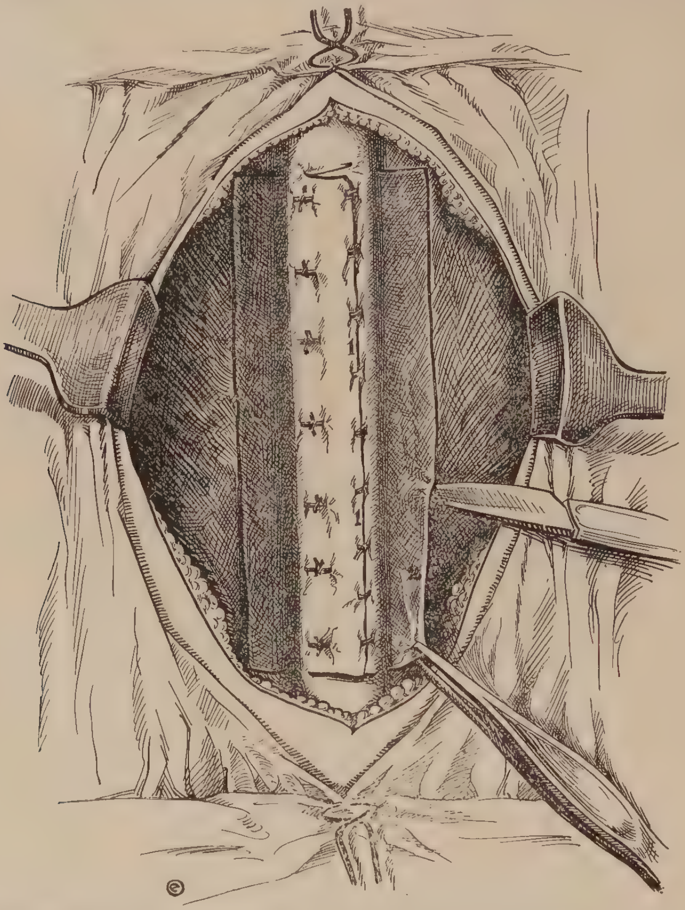

Fig. 7.—Flap Formation to Cover Defect. (1) Sutured flap of inner sac; (2) dissection of flap from vertebral aponeurosis.

Some of the skin sutures are removed on the second or third day, and the remainder as union takes place.

Spina Bifida Occulta.—In spina bifida occulta the field of operation is prepared as described above. An incision, somewhat S-shaped to allow good exposure, is made over the site of the defect, as determined by the X-rays or palpation. If a lipoma overlies the defect, dissection should be carefully made, as a small protrusion often exists under the fat (Bland Sutton). More often the dura is found to be absent or gaping in the cleft. After the cleft has been well exposed, any lipomatous or other tumor tissue lying in the cleft or in the canal should be removed. Bands of connective tissue extending through the cleft, or a plate of fibrous tissue lying over the cleft, should be removed. Any adhesions around the various roots should be divided and the nerve roots freed. As the symptoms in spina bifida occulta arise solely from compression or traction, care should be taken not to attempt to do too much, but merely to free the adhesions around the cord roots. The dura should be drawn together over the roots if it can be done without tension. Otherwise leave the dura open and close the wound as described above. The after-treatment is the same as for the other forms of spina bifida.

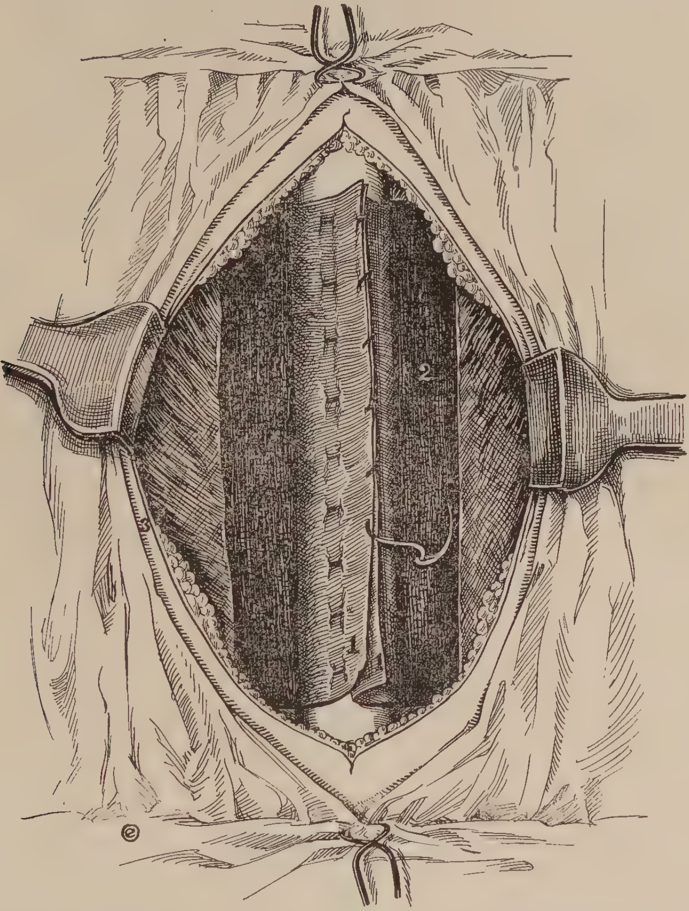

Fig. 8.—Suture of Flaps from Aponeurosis. (1) Flaps brought over to cover defect; (2) raw surface from which flaps were dissected; (3) membranous-skin junction.

Treatment of Complications.—Contractures existing in the lower extremities will require tenotomies; club-foot may require corrective operations or the application of braces; and flail joints may render necessary one of the various fixation operations. These conditions may be remedied at a later time, and corrective measures should not be attempted at the time of the operation on the protrusion.

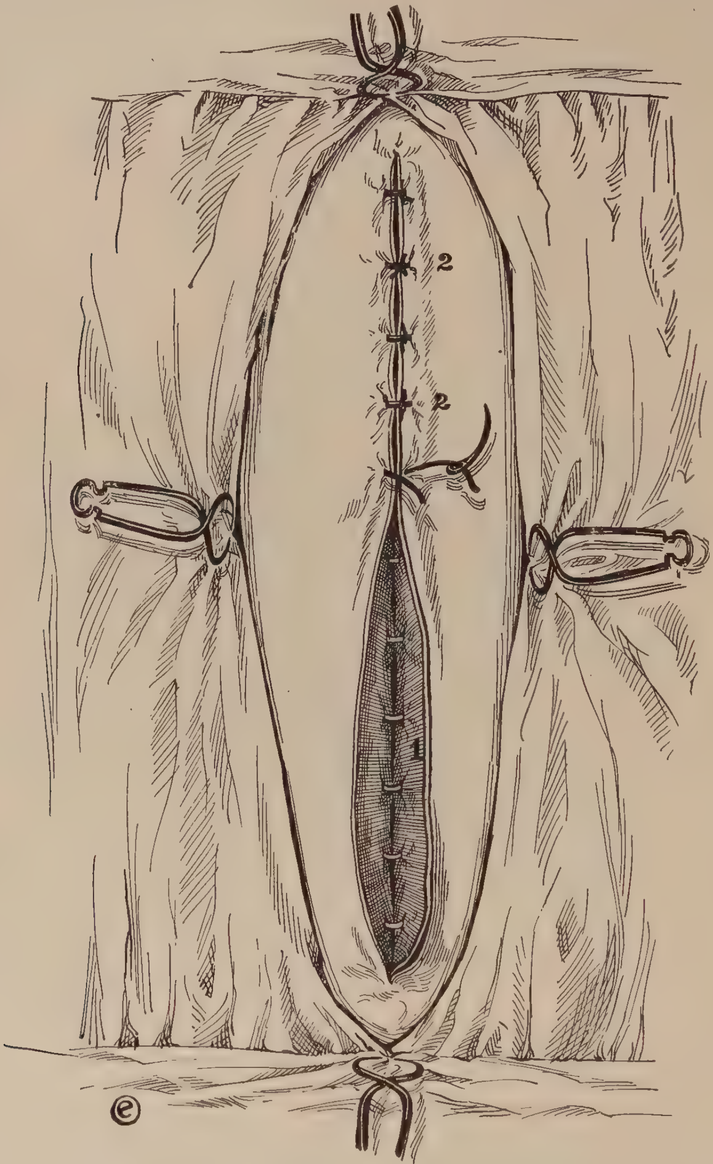

Fig. 9.—Suture of Skin Flaps. (1) Buried suture of catgut; (2) skin edge sutures of silk.

My own series of cases, operated upon in conjunction with Dr. William

Sharpe, in which the method of procedure described above was carried out, now numbers nine. Upon no case have we refused to operate. Naturally, in a condition of absolute paralysis of the lower extremities with complete loss of sphincteric control and emaciation, it would not be considered justifiable to operate. Of these 9 cases, 4 were simple meningoceles in the lumbar region, 2 of which were associated with mild hydrocephalus. Four were myelomeningoceles, all situated in the lumbar region, 3 of which were accompanied by mild hydrocephalus. One was a spina bifida occulta with large bony defect in the sacrum, with partial paraplegia and incontinence of urine and feces. There was no enlargement of the head.

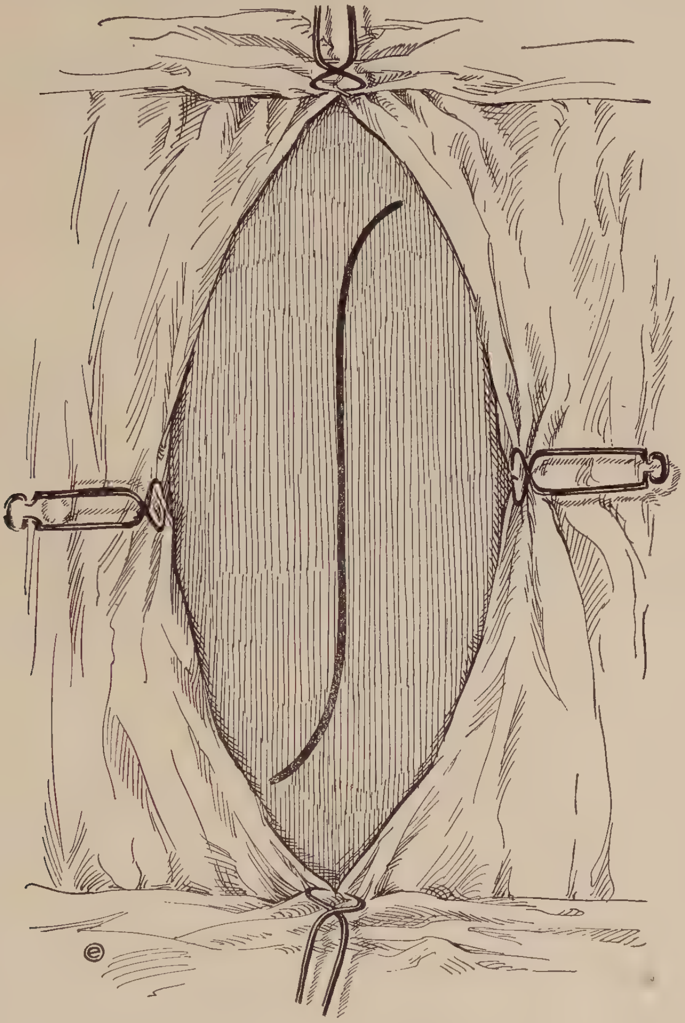

Fig. 10.—Incision for Spina Bifida Occulta.

Of these 9 cases we had 2 deaths from shock 8 hours after operation. Both were large meningomyeloceles in the lumbar region, with large bony defect, which required extensive repair, with consequent loss of cerebrospinal fluid causing the temperature to rise to 106° F. within 3 hours after operation.

In 3 of the cases mild hydrocephalus developed within 3 months after operation. However, in none of these did the enlargement of the head exceed 1½ inches in circumference. In 2 of these cases the lateral ventricles were tapped twice through the outer margin of the anterior fontanel within a month. No further increase in the size of the head has since occurred.

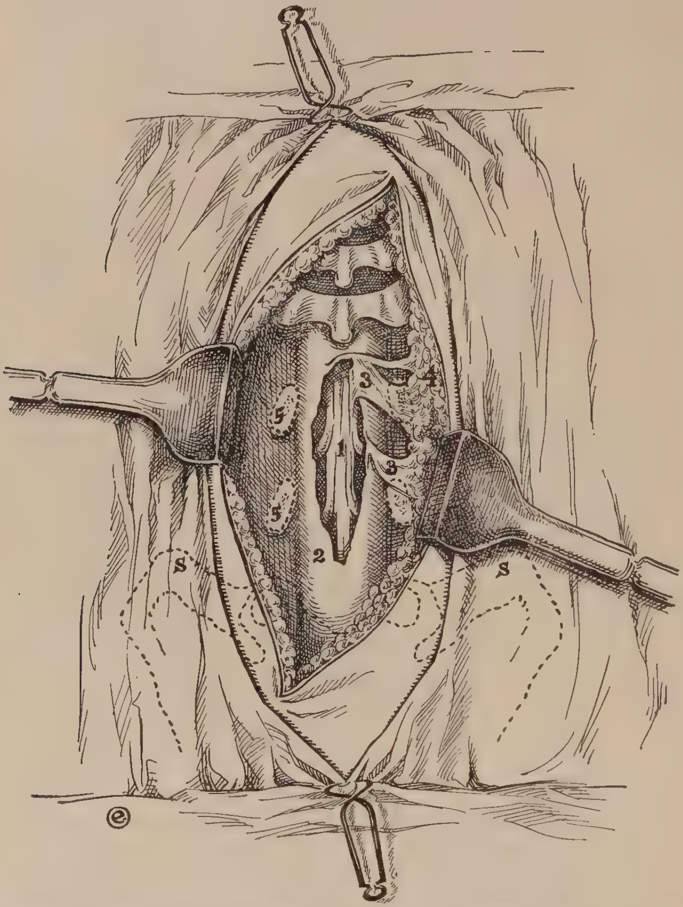

Fig. 11.—Exposure of Defect in Spina Bifida Occulta. (1) Roots of cauda; (2) dura; (3) adhesions to roots of cauda; (4) lipomatous tissue; (5) rudimentary laminæ; (6) outline of sacrum.

In 2 of the cases of spina bifida associated with mild hydrocephalus, the repair of the spinal defect was not followed by any further enlargement of the head.

The remaining 5 cases are all improving, especially as regards the nerve involvement of the lower extremity. In one of these the paralysis of the legs was almost complete, but now the child is moving its legs freely, though still unable to walk 7 months after the operation. In the cases in which there was sensory involvement, it has been interesting to note the quick return of sensation.

SUMMARY

Spina bifida is uncommon, but by no means rare, occurring as it does once in 800 births. If left untreated, practically all of these children would die, 90 per cent. in the first year alone. The only rational treatment is a surgical operation. The practice of operating only upon carefully selected cases should be abandoned. The frequent reports of good, and at times brilliant results that have followed operation upon apparently hopeless cases, renders the surgeon's duty clear in this regard. The only contra-indication to operation that should be considered is the presence of a defect so large that it could not possibly be covered, which is a condition rarely encountered. The operation in itself is not dangerous to life, and even though in many cases there is no improvement in the paralytic symptoms, the excision of the sac renders the life of the child more tolerable and removes a menace to its existence. Over 50 per cent. of these children will recover after operation, a percentage which clearly shows the necessity of surgical intervention.

Rigid asepsis, careful technic and the best of after-treatment, both of a surgical and medical nature, are necessary, if the best results are to be obtained. With a better knowledge of this condition and a constantly improving surgical technic, better results can be expected in the future than have been obtainable in the past.

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CHAPTER XVI

OPERATIONS UPON THE ABDOMINAL WALL

ARTHUR SEYMOUR VOSBURGH

SURGICAL CONDITIONS OF THE ABDOMINAL WALL

Contusions of the Abdominal Wall.—The contusions caused by lesser degrees of blunt violence are accompanied by extravasations of blood in the skin, in the subcutaneous cellular tissue, or in the muscle sheaths. The extravasations of blood spread along the lines of least resistance and, controlled by gravity, seek the inferior and posterior portions of the abdominal wall. The blood, unless it undergoes suppuration—when, of course, evacuation is called for—requires no treatment. Extravasations occurring in the properitoneal layer of the abdominal wall are apt to be very extensive and give rise to considerable difficulty in differentiating them from intra-abdominal conditions.

Rupture of Abdominal Muscles.—Rupture of abdominal muscles results from contusions of the abdominal wall caused by greater degrees of violence, and is apt to be associated with more serious intra-abdominal conditions, such as rupture of intestine or some abdominal organ. In this case the treatment would concern itself with the intra-abdominal condition and the rupture of the wall would be taken care of in the course of treatment of the more serious lesion. Rupture of abdominal muscles may, and often does, occur from muscular violence—as in lifting heavy loads—during parturition, coitus, and as a result of the convulsive contractions in tetanus. Rupture may occur from very moderate degrees of muscular effort in alcoholics, in typhoid, and in cases where the muscular fibers have lost their tone and become wasted as the result of systemic disease.

Suppuration of the subcutaneous injury seldom occurs except in typhoid cases.

Healing usually takes place by the formation of a cicatrix at the site of rupture. Recovery in the cases that suppurate takes place after the evacuation of the pus by granulation of the wound.

The more serious and extensive ruptures may result in hernia and require operative interference for their repair. The lesser degrees of injury are hard to diagnose, owing to the swelling that accompanies the lesion. Immediate repair gives the best results, where the diagnosis is plain, as the torn muscle has not had time to undergo shortening. The procedure is the same as for the general suture of muscle.

In rupture of the recti care should be taken to repair the sheath as well as the muscle when this, too, is torn.

Wounds of the Abdominal Wall.—NON-PENETRATING WOUNDS.—Non-penetrating wounds (not entering the peritoneal cavity) are treated as are similar wounds in other parts of the body.

PENETRATING WOUNDS.—Penetrating wounds result from stabs, pistol or gunshot injuries, or falls upon some sharp object, such as a picket, iron bar, or pitchfork. Extensive lacerated wounds of the abdominal wall involving the peritoneal cavity require immediate repair. Their treatment is conducted along lines of general surgical principles, and there is little chance that one will err in the proper conduct of the case.

On the other hand, one too often sees a young surgeon regard a stab wound as unimportant, or what is equally bad, probe such a tract. Little information can be gained by this that cannot be gained by a safer and more scientific treatment of the wound.

In short, all penetrating wounds of the abdominal wall should be explored under the most careful aseptic precautions, whether we *know* the wound has extended through the peritoneum, or only suspect that it has. If we wait for symptoms to tell us of this catastrophe we have let the time slip by in which we could have remedied the condition, or have minimized its effects.

Gunshot and stab wounds of the abdomen are best handled through a median incision, as the work within the abdomen may be far from the point of entrance. That we may enter the peritoneal cavity in some cases and find nothing cannot be weighed against the surety of having left nothing undone in these cases. It is a small price to pay for safety.

Foreign Bodies in the Abdominal Wall.—Needles may lie in the abdominal wall, having reached there from without; or, having been swallowed, they may have penetrated the stomach or intestine and reached the wall according to their peculiar habit. Other foreign bodies are not so insidious in their approach, and their presence can usually be inferred from the history or the presence of an external wound. Needles seldom give rise to abscess or fistula. The inflammation accompanying the presence of other foreign bodies in the muscle planes or subcutaneous tissues quickly subsides on their removal.

Inflammation of the Abdominal Wall.—MILD CELLULITIS OR LYMPHANGITIS.—Cellulitis or lymphangitis of the abdominal wall arises from small wounds or from the presence of foreign bodies, the infection having entered through the first, or having been carried in by the second, thus setting up inflammation. Where this occurs in the skin or in the subcutaneous tissue, little treatment is required other than rest in bed and the application of evaporating lotions, in the cases of lymphangitis; and the letting out of pus by means of suitable incisions in the cases of cellulitis.

DEEP-SEATED INFLAMMATION OR ABSCESS OF THE ABDOMINAL WALL.—Deep-seated inflammation or abscess of the abdominal wall has been described as a condition peculiar to itself, occurring in the recti or obliqui, in the prevesical space, or in other portions of the properitoneal layer. This method of classifying deep-seated abdominal inflammation is apt to cause confusion by giving the impression that the inflammation depends upon the anatomical structure, and not upon the etiology. The structure of the abdominal wall, its division into layers, and its subdivision into compartments—as in the sheaths of the recti—determine for a time the limits of the inflammation and its boundaries, but in no sense change the character of the disease. The inflammation may be primary or secondary; the infecting agent may reach the particular region from without, through the blood stream, by means of the lymphatics, or by direct extension and continuity. The character and behavior of the inflammation depend on the nature of the infecting agent. The contributing causes—such as a blow or slight strain giving rise to a small hemorrhage, or the slight muscular effort of a typhoid patient resulting in a muscle rupture—may precede the development of the inflammation or abscess by so long an interval as to have been unnoticed or forgotten. Often, on opening an abscess in the abdominal wall or in the properitoneal layer, it is impossible to determine the channels through which the infecting agent arrived. With our present knowledge of inflammation, it seems unreasonable to call such a lesion idiopathic. On the extremities one often sees lymphangitis and lymphadenitis resulting from some small cut or abrasion, long healed, on fingers or toes. If one looked upon all such inflammations as idiopathic—failing to search for the site of infection or disregarding some such small cut or abrasion because it had healed weeks in advance—there would be many called idiopathic, which to-day are known to be otherwise.

Within the abdomen there is not the opportunity to observe the tell-tale course of a lymphangitis, leading from the point of entrance to the site of abscess or inflammation. Infection through the blood stream is doubly obscure.

Abscesses of the abdominal wall resulting, by direct extension along muscle planes or through well-recognized lymphatic channels, from disease of the appendix, gall-bladder, malignant disease of stomach or intestine, or from perirenal inflammation, do not hold their cause so hidden.

INFLAMMATION AND ABSCESS IN THE SHEATH OF THE RECTUS.—Abscess in the sheath of the rectus has for its cause the hematogenous infection of the blood clot resulting from some contusion or rupture of the rectus muscle. As before stated, this is especially apt to follow typhoid. The pus is confined in the strong fascial envelope of the rectus, and for a time is limited to this space. If the abscess lies below the umbilicus, as is usually the case, it is prevented from extending upward by the tendinous inscriptions of the muscle, forward by the strong anterior aponeurosis, downward by the insertion of the muscle into the pubis, laterally by the union of anterior and posterior layers of the rectus sheath. The least resistance to the further extension of the abscess is offered by the posterior sheath of the rectus below the semilunar fold of Douglas. Here the reactionary thickening of the peritoneum usually prevents its extension into the peritoneal cavity. Near the insertion of the muscle into the pubis it can find its way into the sheath of the opposite side.

Owing often to its slow development and its gradual destruction of the muscle fibers, such an abscess may simulate a myositis, which, in fact, is the stage preceding the formation of the abscess.

Treatment should be directed to the early opening and wide drainage of the abscess or inflamed area, with the view of terminating the disease and saving the aponeurotic layers from destruction.

Inflammation and Abscess in the Properitoneal Layer of the Abdominal Wall.—Inflammatory processes occurring in this layer arise, as a rule, from diseases of organs wholly or in part extraperitoneal; from tuberculous or suppurative osteomyelitis of the bones; from inflammations of the bladder, prostate, seminal vesicles, and urethra; and from diseases in the broad ligaments. Retroperitoneal (or properitoneal) inflammation, cellulitis, and lymphangitis represent conditions and stages of conditions arising from infection from organs bordering upon this layer or draining through their lymphatic systems into this layer. Abscess and inflammation in this layer may thus start from disease of the retroperitoneally placed appendix, from the kidney or gall-bladder, and from malignant disease of the colon or stomach. Infection reaching the properitoneal layer from intra-abdominal organs does so through previously formed adhesions, attaching them to the abdominal wall, or through their lymph channels.

Abscesses in the subphrenic, perirenal, and prevesical space (space of Retzius) are not entities, but inflammations occurring in certain definite regions of the properitoneal layer.

Treatment, owing to the difficulty of diagnosis, is apt to be delayed, but it is obvious that the earliest opening and drainage of these spaces should be undertaken to terminate the profound sepsis from which these patients suffer.

Abscess in the Lateral Abdominal Muscles.—Abscesses occurring in the lateral abdominal muscles are, as a rule, secondary to disease of the bones of the thorax or iliac crest. The infecting agent is most often the tubercle bacillus.

Inflammation Due to Extravasation of Urine.—Descriptions of abdominal inflammation cannot hope to approach completeness without mention being made of the type seen in extravasation of urine, where the rupture in the urethra takes place between the anterior layer of the triangular ligament and the deeper layer of the superficial fascia (fascia of Colles). The extravasated fluid, after infiltrating the areolar tissue of the penis and scrotum, must, of necessity, as long as Colles' fascia remains intact, find its way upon the abdomen. As these patients are recumbent when we see them, the fluid makes its way into the loins as well as water-logging the whole lower abdomen. Treatment consists in giving exit to the extravasated fluid through wide incisions, as well as cutting off the source of supply by means of an external urethrotomy.

Hernia and congenital defects of the abdominal wall, such as exstrophy of the bladder, are treated of in another part of this work.

Gastric and intestinal fistulæ result from ulcer or malignant disease or are the result of some operative procedure. Their treatment is considered in another chapter under their appropriate headings.

Tuberculous and syphilitic myositis of the abdominal wall differs in no way from the same disease in other parts of the body.

Actinomycosis of the Abdominal Wall.—Actinomycosis of the abdominal wall may be primary, but is usually secondary to this disease in the intestinal canal. As the fungus is probably taken into the body with food, the site of infection in the majority of cases is in the mouth and neighboring passages. James Israel first established the identity of the disease in man and animals. Israel, and later Hodenpyl, described the disease occurring in the respiratory system. In its involvement of the alimentary canal the stomach and small intestine seem to be less susceptible than the large intestine to the invasion of the disease. Extension to the abdominal wall takes place by ulceration through the intestine, the formation of a granulomatous tumor, further ulceration of the mass accompanied by great proliferation of cells in the connective tissue planes, finally involvement of the skin with the formation, often, of a fistulous tract communicating with the bowel. Infection of the tract occurs from the bowel, giving rise to abscesses in the course of the tract and in the various levels to which the disease has extended in the connective-tissue planes.

This is the usual mode of extension, but where there are marked ulceration and abscess formation it is plain that metastases may occur through the blood stream to all parts of the body. In its progress through the tissue planes the disease seems to spare the muscles, extending along intermuscular spaces, and into the subcutaneous tissue. Such was the case in a patient on whom I and my house surgeon operated a number of times. The disease originated from some focus in the pelvis, just where could not be determined. It formed what felt like a solid tumor in the connective tissue about the bladder, but did not invade this organ. It extended through to the subcutaneous tissue of the lower abdomen, the perineum, and the upper portions of the thighs. In the several operations instituted for the relief of this condition the muscles were involved only at the sites of perforation of the layers, and on wide dissection of the subcutaneous tissue and intermuscular spaces the muscles themselves were found to be free from the disease.

Treatment consists in excision of the fistulous tracts, where possible, and wide removal of all granulating areas. Unfortunately, owing to its nature, the source of the disease cannot often be reached, and our measures for its relief are then only palliative.

Echinococcus Cysts.—Echinococcus cysts are not often found in the abdominal wall. The echinococci (the larvæ of the tænia echinococcus of the dog) finding their way into the intestinal canal through contamination of food and there losing their shell or outer covering, the six-hooked embryos pass through the wall of the bowel, enter the portal circulation—less often the systemic—and undergo development into primary cysts and later secondary or daughter cysts. This process repeats itself, and from the parent and daughter cysts outgrowths arise from the lining membrane into bodies known as scolices, which are in fact the heads of new worms. Each scolex, when transferred to the intestine of a dog, can develop into an adult worm and repeat the cycle of its life history.

As the largest proportion of embryos are carried by the portal circulation to the liver, that is the most frequent site of the cysts in the body. No region of the body, through the medium of the systemic circulation, can be said to be free from their invasion.

CHANGES IN THE CYSTS.—Inflammatory reaction in the tissues surrounding the cyst may wall it off and render it harmless, though the echinococcus may remain alive for years. Death of the parasite means the conversion of the cyst into a putty-like mass, often partially calcified. Rupture of the cyst, if not external, means further transference of the disease. Suppuration of the cyst is the most serious complication.

TREATMENT.—Treatment is purely surgical. Excision should be practiced whenever feasible. Suppurating cysts should be treated as abscesses. See Surgical Operations on the Liver.

Tumors of the Abdominal Wall.—Tumors of the abdominal wall are as various as the tissues from which they spring. Sebaceous cysts, papillomata, and cutaneous moles, owing to the possibility of malignant transformations, had best be treated by excision. Lipomata, discrete and diffuse, may occur in any of the fatty layers. Those near the median line above the umbilicus are discussed in another chapter under the title of Epigastric Hernia. The larger lipomata may require excision.

FIBROMA.—Fibromata of the hard and soft variety occur in the abdominal wall. They show no peculiarities not possessed by fibromata in other parts of the body. The harder varieties spring from the aponeuroses and the tendinous inscriptions; the softer forms begin in the subcutaneous tissues and in the fibrous sheaths of vessels and nerves. The greater frequency of these tumors in women, particularly during the child-bearing period, points rather to a traumatic origin than to any constitutional peculiarity. The term desmoid is descriptive of the arrangement of their constituent elements. As this differs in no way from the microscopical appearance of fibromata in other parts of the body, the reservation of this term to abdominal fibromata seems unwarranted.

Treatment consists in early removal, before the growths have attained large proportions and caused absorption through pressure of the surrounding structures. Removal of large fibromata often entails the sacrifice of tissues adherent to them, necessary to the integrity of the abdominal wall. Hence early removal of these tumors before this stage has been reached is indicated.

CARCINOMA.—Cancer of the abdominal wall is usually an extension from some intra-abdominal organ, often associated with fistula, if the organ is hollow.

Treatment can only be palliative.

SARCOMA.—Sarcomata, as a result of malignant transformations of previously benign tumors, are treated as those occurring elsewhere in the body. Prognosis is bad.

MELANOSARCOMA.—Melanosarcoma occurring in the skin is a part of a general sarcomatosis, and there is no treatment that is of any avail.

Affections in the Region of the Umbilicus.—The variety of conditions calling for surgical interference arising from faulty closure of the vitello-intestinal duct and malformations of the urachus, due to the persistence of that fetal remnant, are too numerous for a detailed description of the surgical procedure required in each instance.

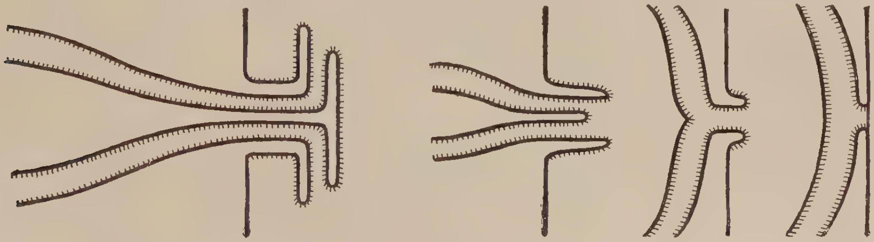

FIG. 1.—VARIOUS TYPES OF THE PERSISTENCE OF VITELLO-INTESTINAL DUCT.

The accompanying diagrams will indicate the conditions requiring interference, and the description of the procedure in each individual case will not be necessary.

The *persistence of the vitello-intestinal duct,* either in the form of a fistula, diverticulum, or cyst, is best treated by opening the abdomen and dealing with it as one deals with the various kinds of fecal fistulæ.

The *urachal malformations* dependent upon the one-time communication of the allantois with the urinary bladder, in their graver and more troublesome forms, are best treated by open operation.

The *diseases of the umbilicus occurring at birth,* such as simple inflammation, arteritis, phlebitis, and the various complications attendant on the healing of the cord, are best treated by the expectant method, as surgical interference —other than the use of proper dressings—is not indicated.

The *tumors* in this region, inflammatory, epithelial, and those arising from the connective tissue, are treated as elsewhere in the body.

INCISIONS IN THE ABDOMINAL WALL

INCISIONS FOR APPENDICITIS

The practice of surgeons has greatly changed in the past 15 years as to the incision best suited to this disease. The change has come about gradually, largely owing to a better understanding of intra-abdominal conditions and the necessity, or lack of necessity, for drainage. It was formerly the rule to drain all acute conditions of the appendix. The oblique incision over the appendix was the one oftenest used, and wide packing of the wound was employed. Suppuration invariably resulted, owing to the introduction of gauze into the wound. The sinuses persisted for 3 or 4 weeks and often longer. Healing took place by granulation, and as a result of division of motor nerves a hernia was a common result.

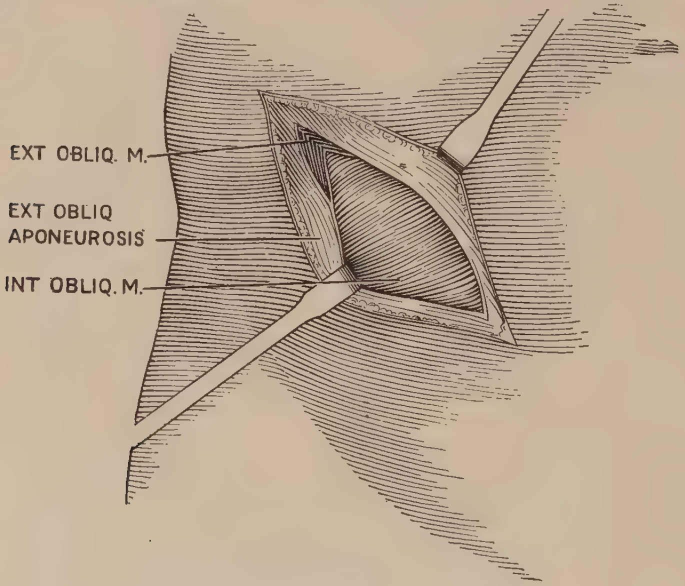

Fig. 2.—McBurney's Incision, First Step.

In the early '90's McBurney described the muscle-splitting operation, which is known as the "McBurney Method." It is of interest to note that McBurney used this only in interval cases and laid stress on the point that it should not be employed in acute cases. At present it is used by most surgeons in acute cases, and some other incision is used where any exploration is contemplated or the diagnosis is at all doubtful.

The McBurney Method.—The incision was devised to avoid division of muscle and aponeurosis and of motor nerves, the tendinous fibers and muscular bundles being separated like the parting of the twigs in a broom, and the motor nerves being avoided by careful separation of the fibers of the internal oblique and transversalis. The advantages of the method are obvious.

TECHNIC.—Beginning at a point 1 in. above the line drawn from the anterior superior spinous process of the ilium to the umbilicus, make an incision through the skin and subcutaneous tissues obliquely downward, crossing this line 1½ inches internal to the spinous process, corresponding as accurately as possible with the direction of the fibers of the external oblique muscle and aponeurosis. Separate the fibers of the external oblique muscle and aponeurosis in a line with, and to the same extent as, the skin incision. Retract the external oblique muscle and the internal oblique will be seen, with its fibers running nearly at right angles to the superficial muscle. With blunt-pointed scissors or the handle of a scalpel, separate the fibers of the internal oblique and transversalis muscles in the direction of their fibers, for here the fibers of the transversalis will be found paralleling those of the internal oblique. The last dorsal and the iliohypogastric nerves will lie on either side of this separation and commonly will not appear in the wound. Blunt retraction will disclose an area of transversalis fascia, which can be increased by further separating the muscles by traction with the fingers. This, together with the peritoneum, is picked up with toothed forceps and carefully divided with scissors.

This incision will be found particularly useful in acute cases where the diagnosis is certain and where we must get in quickly and out quickly with the minimum amount of damage, and where the work within the abdomen is done by the sense of touch. Temporary drainage through this incision will not work harm. Prolonged drainage is apt to hold the muscles in their retracted positions and thus produce a weak area favorable to the development of a hernia.

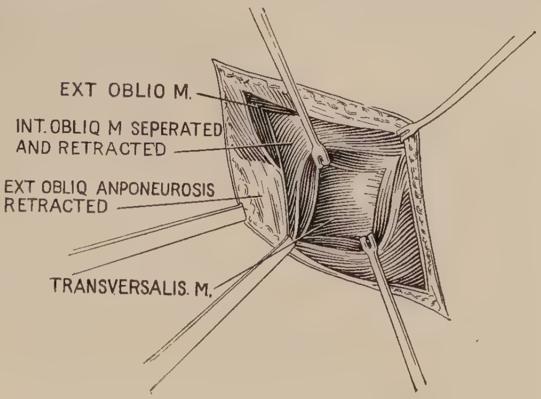
EXT OBLIO M.
INT. OBLIQ M SEPERATED AND RETRACTED
EXT OBLIQ ANPONEUROSIS RETRACTED
TRANSVERSALIS. M.

Fig. 3.—McBurney's Incision, Second Step.

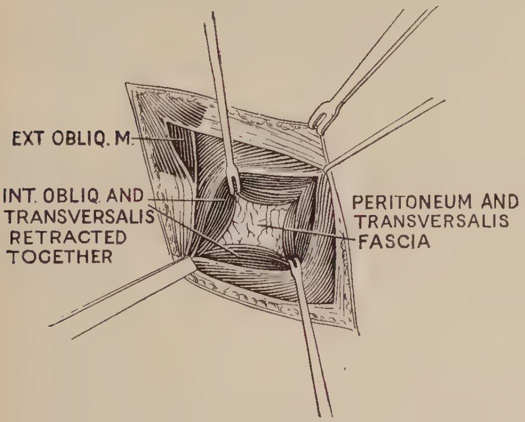
EXT OBLIQ. M.
INT. OBLIQ. AND TRANSVERSALIS RETRACTED TOGETHER
PERITONEUM AND TRANSVERSALIS FASCIA

Fig. 4.—McBurney's Incision, Third Step.

CONTRA-INDICATIONS.—Inasmuch as the McBurney incision does not lend itself to exploration of the abdomen, it is to be avoided in fat men and women, and in other cases where, for any reason, it is thought that the work will have to be conducted deep within the cavity or an extended exploration may be necessary.

EXTENSION OF THE INCISION (WEIR).—If, however, it is found that an error has been made in selecting the McBurney incision in a given case, this incision need not be abandoned. Weir has shown us a way out of the difficulty by extending the line of separation in the internal oblique and transversalis muscles into the rectus sheath, dividing first the anterior layer of the rectus sheath, retracting that muscle, and then dividing the posterior layer after preliminary ligation of the deep epigastric vessels. This extension of the incision will give a greatly wider view of the right lower quadrant.

Right Rectus Incision.—This incision is used by many surgeons for approach to the appendix where a view of the region about the appendix is desired. It is valuable in fat men, and also in women where there is doubt as to the correctness of the diagnosis.

TECHNIC.—An incision is made through the skin and subcutaneous tissues, along the outer border of the rectus, beginning an inch above the line from the anterior superior spine to the umbilicus and extending downward parallel to the curving border of the rectus for 3 or more inches. Split the anterior sheath of the rectus for the same distance, free and retract the muscle belly inward, being careful not to tear the nerves entering it posteriorly. Incise the posterior sheath together with the peritoneum. If care is taken to preserve the

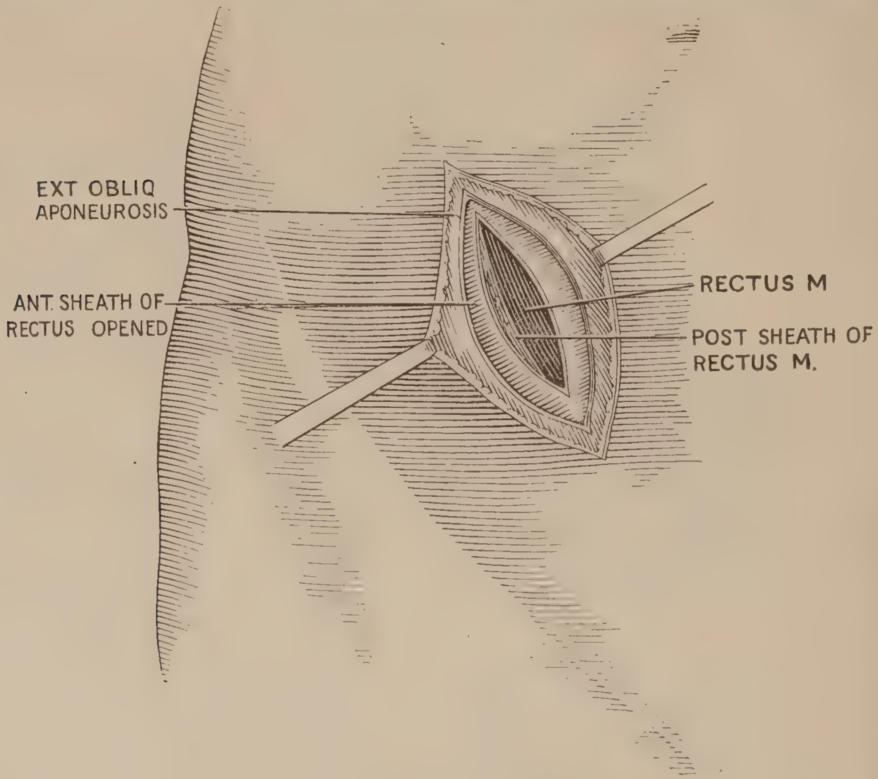

FIG. 5.—KAMMERER INCISION.

nerve supply of the rectus, no more disability follows this incision than the muscle-splitting one of McBurney. The nerves are easily recognized, and by working through the upper or lower limits of the incision, as the case requires, they can thus be preserved from injury.

Instead of retracting the rectus, its fibers may be separated with the closed scissors, the same care being exercised in preserving the nerve supply. The first of these methods is known by a number of names(Kammerer, Battle, Jaboulay).

Horizontal or Davis Incision.—This is simply the Weir extension of the McBurney incision with a horizontal skin cut. The aponeurosis of the external oblique is divided in the same direction as the skin. As union of aponeurosis is equally good whether separated or divided, it possesses the same advantages as the Weir extension method. The middle of the incision is placed at the outer border of the rectus on a level with the anterior superior spine of the ilium.

Other Incisions.—Numerous other incisions are advocated for this condition, but they have no special advantages and lack many of the good points of those described. Where an appendix abscess has pointed, having become adherent to the anterior or lateral abdominal wall, incise over the abscess. If the appendix is not promptly found, prolonged search for it is not advisable. The old oblique incisions are seldom used. High right rectus incisions are sometimes called for (in children especially) where the cecum has not reached the right iliac fossa.

INCISIONS FOR EXPOSURE OF GALL-BLADDER AND DUCTS

The straight vertical incision through the middle or outer third of the right rectus is the one oftenest used in operations on the biliary passages. This incision will suffice for the majority of operations on the gall-bladder and often will be ample for work on the common duct. Individual cases, owing to extensive adhesions, obesity, or any condition preventing proper development of the field, will require enlargement of the wound. This can be done in a variety of ways, as will be described later.

Vertical Incision for Gall-bladder and Ducts.—Make a vertical incision over the right rectus along a line corresponding to the junction of the outer third with the inner two-thirds of the muscle belly, beginning 1 in. below the free border of the ribs. Incise the anterior layer of rectus sheath, and separate the muscle fibers with the handle of a scalpel, sparing the nerves by gentle retraction when this is possible. Incise the posterior layer of rectus sheath together with the peritoneum. In the very muscular this will often be found to consist of a part of the muscle belly of the transversalis. This incision will be found to lie a little to the left of the gall-bladder. Too long an incision will divide the motor nerves and give rise to trouble in keeping the intestines out of the field of operation. If more room is required, the anterior sheath of the rectus can be divided at the upper and inner angle of the wound and the muscle belly retracted inward.

A. W. Mayo Robson's Incision.—Make a vertical incision over the middle of the right rectus. Separate the fibers of the muscle by blunt dissection. Divide the posterior sheath together with the peritoneum. When it is necessary to explore the common, hepatic, or the deeper portions of the cystic duct, continue the incision upward and inward in the angle between the ribs. This incision exposes the upper surface of the liver. By traction on the liver and gall-bladder the organ is drawn downward and forward from beneath the ribs, thus bringing the gall-bladder, cystic and common ducts quite close to the surface. It will now be found that, instead of the gall-bladder and cystic duct making a considerable angle with the common duct, an almost straight passage is found from the fundus of the gall-bladder to the entrance of the bile-duct into the duodenum, and if adhesions have been thoroughly separated, the surgeon has immediately under his eye the whole length of the ducts with the head of the pancreas and duodenum. (Robson, 6.)

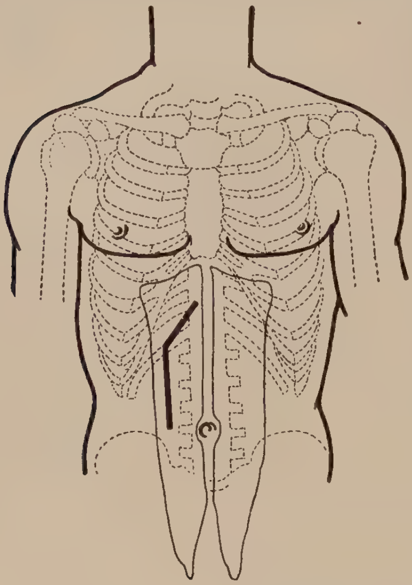

Fig. 6.—A. W. Mayo Robson's Incision.

Kocher's Oblique Incision.—Make an incision parallel to the free border of the ribs and about 2 in. distant. This incision divides the muscles of the abdominal wall obliquely and gives wide exposure of the region. Repair of the

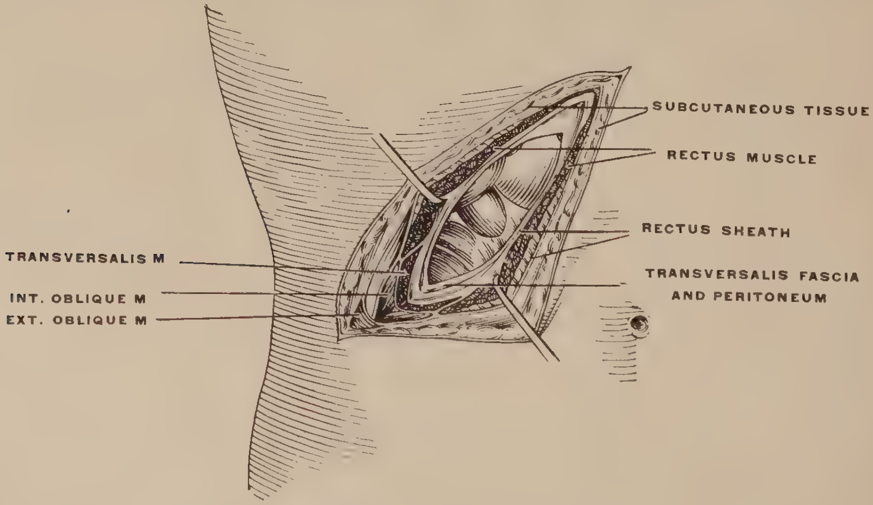

Fig. 7.—Kocher's Oblique Incision.

wound requires very careful suturing, and if drainage is employed, is very liable to be followed by hernia. As the intercostal nerves run upward and inward in this region, they can be avoided, but the cross division of muscle is apt to work harm unless very careful repair and non-drainage of the wound are practiced. As drainage is necessary in the greater number of these operations, the incision has not achieved popularity in this country. Posterior drainage through the right loin (as practiced by Rutherford Morison) does away with this objection to the incision.

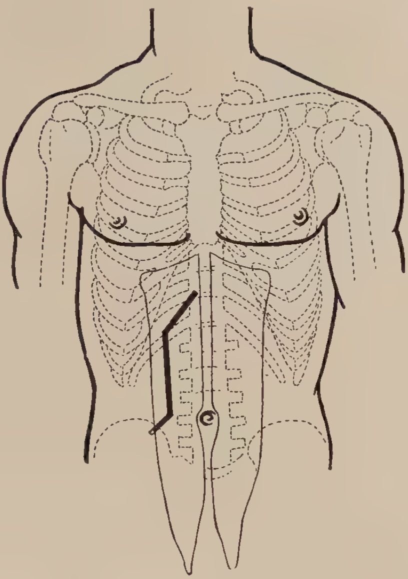

FIG. 8.—BEVAN'S INCISION.

Bevan's Incision.—Bevan uses the vertical incision for all operations requiring little room, but where it is necessary to obtain more, prolongs the straight incision upward and inward (as does Robson), and downward and outward, as shown in Figure 8. To the majority of operators the lower extension has proved of little help.

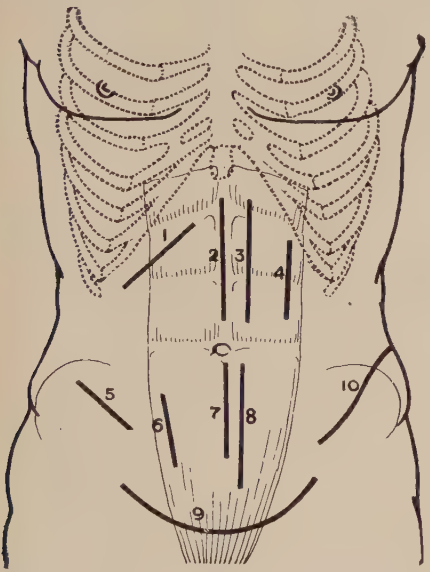

FIG. 9.—INCISIONS. 1, Kocher's incision; 2 and 7, median incisions; 3 and 8 paramedian incisions; 5, McBurney's incision; 6, Kammerer's incision; 9, Pfannenstiel's incision; 10, lower position of incision for ureter.

In all operations on the biliary passages a better exposure can be obtained by the use of a sand bag or Lilienthal's bridge placed under the lower portion of the thorax.

INCISIONS FOR OTHER ABDOMINAL CONDITIONS

Pfannenstiel Incision.—Pfannenstiel's incision for approach to the structures and organs in the lower abdomen is made by means of a slightly curved cut (concavity upward), carried through the skin and anterior sheath of rectus. The incision lies in the region commonly occupied by the pubic hair, and follows the curve of the crest of the pubis and the sagging margins of Poupart's ligament on either side. The proximal flap of skin, superficial fascia, and rectus sheath being reflected upward, the recti are exposed. The recti are drawn to either side and the peritoneum divided.

The advantages of this incision are: the muscles are separated and not divided; no nerves are severed; the resulting scar is strong; and it has cosmetic value, inasmuch as the scar is hidden.

The approach to the upper and lower abdomen for operations on the liver, stomach, pancreas, and spleen, and for structures in the pelvis, is best accomplished by incisions through the recti. Unusual conditions call for unusual incisions, and the description of incisions used in particular instances forms no part of a work on the general subject of incisions.

Particular incisions or methods for such operations as gastrostomy, colostomy, and the incisions for kidney and ureter are considered in the chapters dealing with the operations on these viscera and organs.

ABDOMINAL SECTION; LAPAROTOMY; CELIOTOMY

General Considerations.—The abdominal surgeon has 2 objects to accomplish: first, the proper exposure of the field or region demanding surgical interference, that the work may be done thoroughly and expeditiously; second, the preservation of the abdominal wall from subsequent hernia. That these must be accomplished with the minimum degree of injury to the parietes is axiomatic. The proper exposure of the field of operation, the speed in doing this, the careful accomplishment of the essential part of the operation, the proper closure of the abdominal wound, all make toward a successful result. **The too small wound, the poorly developed field, the stumbling technic, the finical attention to the non-essential, mark the poor surgeon and add immeasurably to the length and dangers of the operation.**

The advance of aseptic surgery, while rendering safer all abdominal operations, has at the same time led many untrained and "occasional operators" to attempt an incursion into the field of surgery for which, by education and previous training, they are in no way fitted. The most careful examination may only allow the surgeon to make a tentative diagnosis, and he must be equipped to undertake and carry through some of the most difficult and technically complex operations in abdominal surgery. He must be thoroughly grounded in the anatomy of the abdomen, not only as seen in the dissecting room, but also as seen in the field of an operation. His sense of touch must be well developed that he may recognize things not seen and know the feel of things pathological as well as anatomical.

The young surgeon, betrayed by the clearness and the apparent ease of the steps of an operation as shown by the too perfect plates of some operative surgery, may find himself in the midst of the greatest effort of his life; and fortunate is he if he has been well grounded in one of the fundamentals of a good surgeon, a thorough knowledge of anatomy.

Balance, a rare quality, is an added asset. The surgeon possessed of this attribute will be better able to settle the many problems requiring quick decision that confront the abdominal operator.

The abdomen is opened for injuries and diseases of its contained organs and viscera, for anomalies of development, for displacements due to injury or disease, and for conditions formerly thought to belong exclusively to the domain of medicine. So greatly has the field of abdominal surgery enlarged, not only because of the wider scope of the surgeon's own endeavors, but because of the inclusion of this latter class, that many patients not mortally ill resort to surgical treatment. These, not driven by pain or fear of a grave disease, seek help for relief of conditions which, if surgery is to be of avail, must be cured without a constant reminder of the means employed to the end. The man or woman saved from an intestinal obstruction or a spreading peritonitis counts as little the resulting scars and painful cicatrices. Even a ventral hernia would be thought a small price to pay for escape from impending death. This tolerance of surgical work does not obtain among those not seriously ill. To them the surgeon must bring a skill and a refinement of his art that will enable him to invade the abdomen without leaving in his wake a train of suffering. How this may be done comes under the head of general abdominal technic and the study of abdominal incisions.

GENERAL ABDOMINAL TECHNIC

Preparation of the Patient.—In addition to the diagnosis of the local condition and a careful estimate of the benefits to be derived from the operation, a thorough physical examination of the entire body should be made, the function of the kidneys carefully estimated, and all laboratory and pathological findings recorded. A compensated heart lesion should not stand as a contraindication, provided the indications for operation outweigh the risk, as such patients bear an anesthetic well. Under the same conditions a recognized renal lesion should warn one that the anesthesia should be of the briefest and lightest compatible with the accomplishment of the object.

The bowels should be emptied by a cathartic given the night before operation, followed by enemata in the morning. Prolonged attention to the bowels is not advisable and is apt to give rise to postoperative complications.

The diet, too, is best not interfered with, except in cases of diabetes, obesity, and nutritional disorders, in which, of course, special feeding is of the utmost importance. Solid food is withheld during the 12 hours previous to operation. Small amounts of fluid may be given during this time. Long preliminary preparation and special dieting are, in the ordinary case, next to useless, as it centers the mind on the operation and thus defeats its purpose. Anticipatory dread is enough to disturb normal digestion, and anything that prolongs and intensifies it is to be avoided. This, however, does not mean that everything should not be done to get the patient in the best possible condition provided sufficient time is available. In emergency cases where the preliminary preparation is completed within an hour one often sees less postoperative disturbance than in cases that have undergone a longer preparation. The majority of these patients look to the operation as a means of relief, and there is little functional disturbance other than that caused by the disease.

The routine administration of morphin and atropin shortly before operation has a markedly beneficial effect in controlling nervousness and materially diminishing bronchial secretion. It increases the effect and diminishes the amount of the anesthetic required.

It is of extreme importance that all preparation should be carried on quietly and without hurry, and that the demeanor of those about the patient should be interested but not anxious. The conduct of the surgeon and his assistants goes a long way toward allaying fears and inspiring confidence in the successful outcome of the operation. Too often the nervous or irritable surgeon imparts some of his lack of equilibrium to a young and inexperienced nurse or doctor, and the result is not happy. Preparedness on the part of the surgeon and of his assistants will obviate much of this, but the hurrying and fault-finding surgeon will never be well served.

PREPARATION OF THE FIELD OF OPERATION.—The details of sterilization of instruments, dressings, gowns, and operating-room furniture, and the preparation of suture material are treated elsewhere in this book. The two methods most in vogue in preparing the field will here be contrasted.

The older method of preparation with vigorous scrubbing of the abdomen, the green soap poultice or wet antiseptic dressing left on overnight, followed by more scrubbing just before operation, is happily a thing of the past. The operators who still prefer this method have modified it by eliminating the wet poultice or antiseptic dressing (left on over night) from the preparation. A dry sterile dressing is substituted and left on till the final washing with green soap, alcohol and ether, and sterile salt solution.

In the majority of clinics the dry preparation with iodin is most in use. This method, known as Grossich's, has many advantages. It is especially adapted to emergency cases. Grossich lays special stress on not using any watery solutions before the application of the tincture of iodin. If this is observed, the epithelial cells will be dry, and deep penetration of the iodin will take place. There is no issue as to the sterilization by either method. The advantages of the iodin preparation over the older method lie in its universal applicability for fresh incisions, for open wounds, for infected wounds, for speed, and, lastly, for cheapness.

According to this method, the patient lies on a dry table, not subjected to the chilling effects of evaporating lotions, the bodily heat being thus more easily maintained. The main objection urged against this method is the fear of a chemical peritonitis, increasing the danger of postoperative adhesions. Now that we are aware of such a possibility, it may be avoided by protecting the peritoneum from contact with the iodin by means of pads clipped to the sides of the incision, or by clipping the wound edges to sterile towels.

CLOTHING OF THE PATIENT FOR THE OPERATING ROOM.—This should be carefully considered. Closed leg drawers of canton flannel, warmed blankets over chest and legs, and the pneumonia jacket for old people are among the necessary parts of the outfit. Appliances for warming the table are very useful in long operations, but must be watched with the utmost care for fear of burning the patient. As a rule they are not necessary if due care is exercised in other ways for the protection of the patient. Too much stress cannot be laid on not allowing the patient to lie during a long operation in a pool of water. This will not occur with the iodin preparation, or if one is careful in the use of irrigating fluids during the operation.

The Operating Room.—This is discussed fully in another part of this work. Suffice it to say that, given a good northern light, the keynote should be simplicity. In the matter of furnishings, a suitable table provided with head and foot elevations and kidney ridge, 2 movable tables, 1 for instruments and 1 for dressings, and 2 stands for hand douches, are all that are essential. Sterilizers for instruments, dressings, basins, and pitchers and the etherizing rooms should all be outside the operating room.

When operating in the patient's home, the same simplicity should mark the preparations. The room should have as good a light as can be secured, with the curtains removed from the windows and the latter draped with cheese-cloth or soaped. Other cleaning is unnecessary, provided the operator and his assistants keep constantly in mind the asepsis of the surgical field. In other words, one may operate with perfect safety in a barn or shed, provided the aseptic integrity of the surgical field is preserved. This rule holds good when the region near the proposed incision cannot be rendered sterile. I have operated on an acute appendix in a patient suffering from erysipelas, where the line of redness on that side came to Poupart's ligament, and secured primary union in the operative wound.

In field hospitals in war time the greatest problem is dust, for where great bodies of men have fought the atmosphere is apt to be laden with it. If the emergency is not too great, it is better to delay operating until freedom from dust can be secured.

Assistants.—One assistant besides the anesthetist is sufficient in the majority of abdominal operations. There should be one "sterile" nurse for instruments and dressings, and one "non-sterile" nurse for work about the operating room not bringing her in contact with the field of operation. A well-trained orderly for the heavy work, such as lifting patients on and off the operating table and cleaning up between operations, is of great assistance. A second surgical assistant is at times necessary, but it is better to learn to work with as few as possible coming in contact with the wound.

Position of the Operator.—A right-handed operator should be on the right of the patient, a left-handed operator on the left. In pelvic work it will often be convenient to change one's position from one side to the other so as to bring the palmar surface of the fingers to bear on the organ or structure being handled. Operators of short stature require a low, broad foot-stand to raise them to an easy position, especially for work on a patient in the Trendelenburg posture.

Position of the Patient.—For ordinary abdominal operations the dorsal position is the best with which to start, and in this position all exploration of the abdomen should be done.

If the operation is a pelvic one, the patient is put in the Trendelenburg posture after the abdomen has been opened and all exploration completed. On terminating the operation, the patient is lowered to the dorsal posture for the closure of the abdomen.

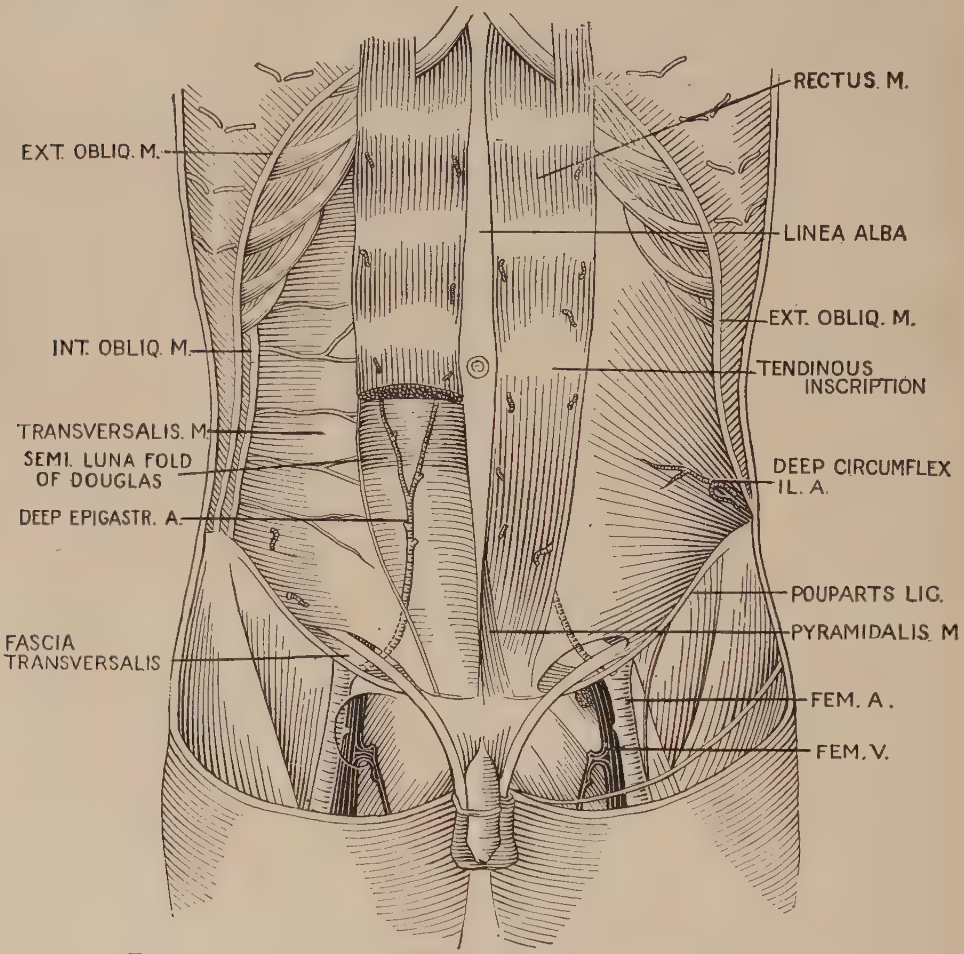
RECTUS. M.
EXT. OBLIQ. M.
LINEA ALBA
EXT. OBLIQ. M.
INT. OBLIQ. M.
TENDINOUS INSCRIPTION
TRANSVERSALIS. M.
SEMI. LUNA FOLD OF DOUGLAS
DEEP CIRCUMFLEX IL. A.
DEEP EPIGASTR. A.
POUPARTS LIG.
PYRAMIDALIS M
FASCIA TRANSVERSALIS
FEM. A.
FEM. V.

Fig. 10.—Musculature and Nerve Distribution of Abdominal Wall.

Similarly, when the work is in the upper abdomen, gall-bladder, or stomach, the incision should be made while the patient is in the dorsal position. He should later be elevated, if necessary, by means of the kidney bridge to give the exposure required; and again lowered to allow for closure of the wound under conditions of less strain.

Renal and ureter operations in general require the prone or semiprone position, with the kidney bridge or Edebohls' cushion to give the necessary prominence to the loin.

Closure of the abdomen, in conditions of marked distention, is sometimes facilitated by raising the head of the operating table and thus obtaining greater relaxation.

The Incision.—In considering how best to approach some organ or region with the least possible amount of damage one will be repaid by a contemplative review of the abdomen as to its boundaries, musculature, and the distribution of the motor nerves to its walls. Thus we may visualize the abdominal cavity as an oval in its coronal and sagittal planes and as reniform in cross section, bounded above by the diaphragm arching under the wide springing ribs, below by the levator ani dipping into the pelvis, its walls partly bony, mostly muscular, giving content to its organs and viscera. The 4 pairs of muscles through which we must go in the great majority of abdominal operations are the recti, the transversali, and the obliqui. Briefly, the 3 pairs of lateral abdominal muscles arise posteriorly from the adjacent ribs, the lumbar aponeurosis, and iliac crest, and are inserted anteriorly by means of their aponeurotic expansions in the median line, forming the linea alba; having first split in their upper three-fourths to form the sheath of the recti, in their lower fourths all 3 expansions pass in front of the recti. The lower dorsal and 2 upper lumbar nerves are distributed to this muscular wall in serial order, a pair of nerves distributing filaments to each somatic layer, lying first between the transversali and the internal obliqui, finally ending in the recti, having pierced their posterior sheaths.

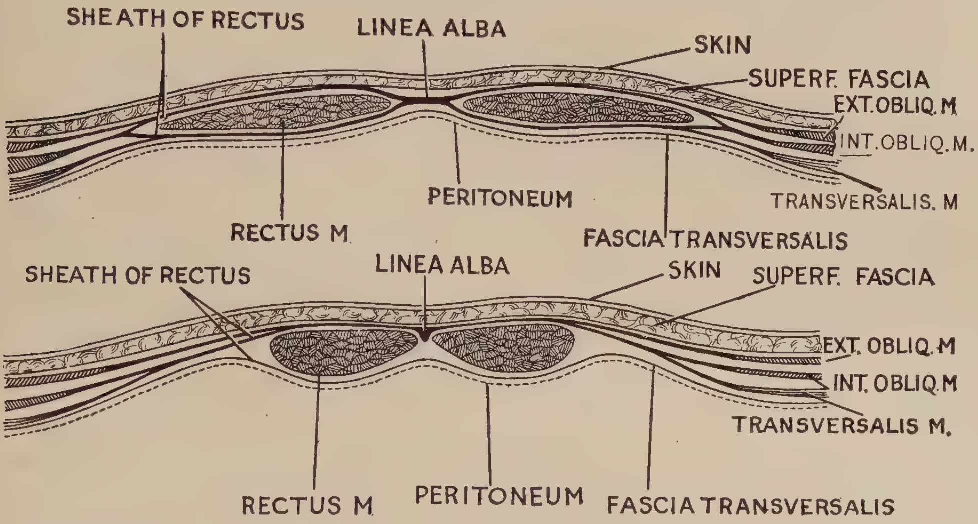
SHEATH OF RECTUS
LINEA ALBA
SKIN
SUPERF. FASCIA
EXT. OBLIQ. M
INT. OBLIQ. M.
PERITONEUM
TRANSVERSALIS. M
RECTUS M
FASCIA TRANSVERSALIS
SHEATH OF RECTUS
LINEA ALBA
SKIN
SUPERF. FASCIA
EXT. OBLIQ. M
INT. OBLIQ. M
TRANSVERSALIS M.
RECTUS M
PERITONEUM
FASCIA TRANSVERSALIS

Fig. 11.—Cross-section of Abdominal Wall Above and Below Semilunar Fold of Douglas.

This being the material upon which we must work, we have the choice of several methods in gaining access to an organ or region of the abdomen: Incision through fascia, muscle splitting, muscle retracting, muscle splitting and retracting, and, lastly, muscle division.

Incisions through fascia, i. e. the median line, while avoiding nerve division, are apt, owing to the tendency of connective tissue to stretch, to give us weaker scars. Most surgeons go to either side of the median line and split the recti or retract them, thus obtaining a stronger union.

In muscle-splitting operations, as practiced in the McBurney operation for appendicitis or for left-sided colostomy, care should be exercised not to tear or divide any motor nerve that may be running near or across the split. The same may be said in muscle-retracting operations as, at the outer border of the rectus below the level of the umbilicus (the Kammerer incision), it is possible, if care is taken, to avoid the nerves entering the rectus by means of gentle retraction or by working through the upper or lower portions of the incision, as the case may require.

The disabling effects of muscle division, necessary in many operations, may be minimized by careful suturing of the retracted ends. Division of a muscle through its belly, provided its nerve supply is not disturbed, is not so disabling as one would at first suppose. The recti are interrupted by tendinous inscriptions, and the portions of the muscle between these inscriptions have an independent nerve supply; it is thus possible to divide these muscles transversely near a tendinous inscription and, after suturing, get little or no loss of function. We know that these inscriptions do not all extend through the entire thickness of the muscle, but that portion of the muscle subtending any one inscription is apt to have a double nerve supply, as the parts above and below the inscription have an independent supply.

Postoperative hernia, as well as primary hernia, has as a contributing cause the out-pouting of the peritoneum from the generally smooth contour of the interior of the abdominal cavity. The intestines, under conditions of strain, find these reëntrant angles or pouches, and if the pouch is not well supported at its back a hernia is bound to occur.

These reëntrant angles or pouches may come to be formed in a number of ways. There are those which are normally in the lower abdomen, formed by the peritoneum being thrown into folds by the urachus, the obliterated hypogastric, and the deep epigastric arteries; another, where the peritoneum dips beneath Poupart's ligament, tending to enter the femoral sheath. The occurrence of hernia through the lateral inguinal fossa leading to the pre-formed processus vaginalis is too common to require mention. The pouch on either side of the urachus is too well protected by the insertion of the recti to allow hernial protrusion. The mesial inguinal fossa and the femoral fossa are often the sites of hernia. Herniæ into the inferior duodenal fossa, intersigmoid fossa, and through the diaphragm are all examples of how a pouch of peritoneum, unless strongly protected from further protrusion, acts as a causative factor in the production of hernia.

This outpouring of the peritoneum occurs, following operations on the abdominal wall, from faulty closure of the peritoneum; from paralysis of a muscle, its motor nerve having been cut; from suppuration in the wound, with destruction of muscle and fascia which should have acted as a barrier; and from too long-continued drainage allowing the fast proliferating endothelium to extend itself along the tract of the drain. In muscle-retracting operations, where it has been necessary to use a drain, the retracted muscles are apt to become adherent one to the other in their displaced positions, thus leaving a weak area along the line of separation.

LENGTH OF INCISION.—For exploratory incisions, whether made under local or general anesthesia, a length of 2 or 3 in. will be found ample to give information by sight and touch. The exploratory incision should be so placed that, on finding that the operator may proceed, it may be utilized by simple extension for the operative procedure.

Many uncomplicated operations may be performed without introducing the hand into the abdomen. For such a small incision is all that is required.

In operations for the removal of large tumors, or where the operative work is carried on at a great depth, longer incisions are necessary. Where one is hampered by a small incision, or is needlessly prolonging an operation by trying to work through too small a wound, it is good judgment to promptly enlarge the wound. Too many surgeons think they have done full justice to their patients if they have followed strictly the steps of an operation and done their work through a small incision; forgetting, or at least losing sight of, the fact that they have added immeasurably to the shock of the operation by rough handling of the intestines necessitated by the small incision, and increased its dangers by prolonged anesthesia.

For *injuries,* gunshot and stab wounds of the abdomen, the paramedian incision, either above or below the umbilicus, will be found oftener to fulfill the requirements. In these injuries there is little likelihood that the work within the abdomen will be carried on in the neighborhood of the superficial trauma.

For *reëntering the abdomen* about a hernial protrusion, near an old cicatrix, or where one fears the intestine may be adherent, it is best to circumscribe the old scar or, having reached the peritoneum, to pick it up and try it here and there until one is satisfied that he has found a spot where it is safe to enter. If it is found that further work must be done in another part of the abdomen, the original incision should be abandoned and a second one made. It is poor surgery to attempt to do work at a distance from the seat of trouble; or to extend the original wound to reach the new field by dividing motor nerves, the inevitable result being paralytic hernia.

Treatment of the Open Wound.—As soon as the abdomen has been opened, hot, moist gauze pads should be clipped to the sides of the incision in order that coils of intestine or eviscerated organs may be received on a surface that will cause the least degree of trauma and prevent loss of heat. If coils of intestine have to be kept outside the abdomen for any length of time, they should be received in hot towels, and these renewed from time to time. The operative field having been developed and the operation being a clean one, no walling off of the field with gauze packing is necessary. The gauze pads, even when moist, are liable to traumatize the delicate peritoneal cells, or by getting in one's way to narrow the field and lengthen the operation.

When soiling of the field is likely or to be feared, broad, moist abdominal pads should be placed about it and not disturbed until the operation is finished. Lesser pads may be placed in the wound and renewed from time to time. The changing of these will not soil or traumatize the regions protected by the larger pads.

All sponging had best be done with moist gauze, well wrung out, mounted on "sponge holders." Adherent omentum can often be pinched off without exciting hemorrhage. When this cannot be done, its division with chain ligatures on the proximal side is the safest plan.

Adhesions.—When of recent formation, adhesions are easily broken down by gentle pressure with the fingers, causing little bleeding. What bleeding does occur is easily controlled by temporary packing with hot, moist gauze. Older adhesions about old inflammatory processes in gall-bladder, stomach, tubes and ovaries, and those about malignant growths, give much more trouble, and their separation must be undertaken with the greatest care. A bowel in contact with inflammatory processes is apt to have its walls swollen and edematous, and any rough handling of the adhesions will open its lumen. Patience and great care must be exercised in their separation, pushing gently with the fingers where a line of cleavage may develop, dividing between ligatures where stronger bands exist, avoiding too close approach to the bowel where its lumen is in danger. Large broad areas of adhesions binding coils of intestine together, where there is no angulation or undue narrowing of the gut, had best be left alone. All bands or free running cords, about which a loop of gut might become strangulated, must be divided.

The tendency of the peritoneum to form adhesions about some infective focus or perforation is a life-saving function. The reproductive or proliferative power of the peritoneal cells renders possible the many operations on the intestines. Few would have successful results in intestinal work depending solely on their technic for the outcome, were it not for the fact that the peritoneum cements in one's line of suture in a few hours. This protective power of the peritoneum is utilized in many operations where a region is to be walled off, or a tract or channel established from some suppurating focus or doubtful organ to the external wound. This is done by drains, temporary packing, and the like, to make the communication desired between the operative field and the skin incision. This protective peritonitis from trauma or infection is the key to success in the majority of abdominal operations. The power of the peritoneum to wall off a threatened area and hold it quarantined until the surgeon can relieve the primary condition renders abdominal surgery possible. Otherwise, the larger proportion of patients would be beyond help before surgical aid could be brought. A knowledge of how the peritoneum behaves under such conditions should teach us that, if one relieves the primary condition, he need pay no attention to the surrounding peritonitis, as that will take care of itself.

The power of individuals to form adhesions in the peritoneal cavity is not uniform, sometimes being dependent on what is called resistance or immunity, sometimes, on the other hand, on predisposition. In some cases, however, it is simply fortuitous, depending on the slow development of the trouble, as an inflammatory focus or the gradual perforation of a hollow viscus. Where the infection is fulminating or where the hollow organ is full of infectious material when perforation occurs, large quantities of material are poured out at once; the peritoneum is then overwhelmed and there is no time for adhesions to form, the result being a general peritonitis. Inflammatory or protective adhesions have likewise great power of reabsorption after the cause that brought them into existence has disappeared or been removed.

There yet remains a class of inflammatory and postoperative adhesions that requires careful consideration, because of their power to disturb function and cause pain. When disturbance of function results from adhesions caused by some previous inflammatory process, relief can usually be brought about by removal of the diseased condition and freeing that portion of the mass of adhesions giving rise to the disturbance of function. The same applies to adhesions resulting from some operative procedure, but one should ever bear in mind how, by perfecting his operative technic, he may prevent their formation in the first instance.

The means of prevention may be summarized as follows: proper and ample incision; one complete and final exploration; development of one's field; gentle retraction; gentle handling of the intestines; use of moist gauze; avoidance of chilling or drying of intestinal coils; use of non-irritating irrigation; the speediest possible performance of the operation; avoidance of sepsis; avoidance of drains, where possible; their early removal, when used; proper rest of the wound; frequent change of position that does not disturb the wound during the first few days subsequent to operation; stimulation of intestinal movement by enemata and colonic irrigations.

Hemorrhage.—Hemorrhage is best controlled by tying all bleeding points as they appear. Clamps left on severed vessels soon accumulate and hamper the work in the wound. Only the bleeding point should be seized and as little adventitious material as possible included in the ligature.

Aseptic thrombi do not break down nor furnish emboli to be carried to other parts of the body. Large masses of tissue shut off from their blood supply by ligatures have to be taken care of by the peritoneum; and if they have been subjected to much handling and consequent trauma, their partial disintegration may interfere with aseptic thrombus formation in the neighboring vessel.

When it is known or previously recognized what vessels are to be severed, they should be divided between clamps and then ligated. Subperitoneal hemorrhage in bowel or mesentery should be promptly controlled by ligature passed on a fine needle. (I prefer to use an aneurysm needle with fine catgut.—Editor.)

If the habit of securing only the vessel is practiced, ligature material other than catgut will seldom be required. This will aid in obtaining prompt and permanent healing of the wound, as it eliminates the possibility of troublesome sinus formation from silk ligatures placed on infected pedicles. The peritoneum will perform the most wonderful feats of absorption, but silk ligatures it cannot digest. All it can do is to encapsulate foreign non-absorbable material, and then only when the foreign substance is absolutely sterile as well as the tissues in which it lies.

Hemorrhage from a large area in the form of persistent oozing, such as occurs following the enucleation of a tumor or inflammatory mass from its bed, must be controlled by a pack; this is due to the mouths of the minute vessels being held open by the surrounding inflammatory thickening and rigidity of the tissues. The tampon described by Mikulicz is the best for this purpose. Every effort should be made to control the oozing by temporary packing of the space with hot moist gauze, the Mikulicz gauze tampon being used only as a last resort. Its use necessitates wide drainage of the wound, which should be avoided whenever possible.

The thermocautery has a limited field of usefulness in controlling hemorrhage within the abdomen; only where the spread of malignant disease is feared may it be used, when, by sealing the mouths of lymphatics and venous channels, it prevents transplanting of dislodged malignant cells on adjacent raw surfaces.

Drainage.—This opens a wide field for discussion, and as the battle of opinions has been very thoroughly fought out, it will be sufficient here to give only a brief consideration of the subject.

One must have a very clear idea of what he is going to accomplish by drainage, and an equally clear understanding of the conditions calling for it.

An abscess must be drained whether it lies within or outside the abdomen. If it is deep within the abdomen, and access to its interior cannot be gained except by traversing the peritoneal cavity, then this must be done and means provided for the safe conduct of the infectious material to the surface of the body. This is effected by means of gauze packing leading from the external wound, across the peritoneal cavity, to the site of the abscess. By virtue of the power of the peritoneum to form adhesions about a foreign substance, a tract is soon formed around the packing which, when the gauze is removed, gives exit to the contents of the abscess under conditions of safety.

Hemorrhages or abscesses of the pancreas must be dealt with in the same manner. Ovarian cysts, whose walls cannot be removed owing to surrounding inflammation, may be stitched to the margins of the abdominal wound or drained in the same manner as cysts of the pancreas.

In operations on the bile-passages drainage of the common duct must be practiced when made necessary by reason of infection: first, in order to wall off this region from the general peritoneal cavity; second, to provide a means of escape for bile that may leak from the rubber tube placed in the duct.

Anastomosing operations on the large intestine require drainage, as suture of this portion of the alimentary tube cannot be depended upon and a tract must be provided from the site of the operation to the external wound. Not to drain in these operations is to run an unnecessary risk.

In operations where large shreds of inflammatory tissue have to be left, or where the viability of a portion of the bowel wall is in doubt, drainage is necessary.

Whether to drain or not in a given operation must be left to the judgment of the individual operator. To formulate a rule by which one may be guided in all cases is very difficult. It would seem an easier matter to present certain concrete examples, stating in each instance what considerations should guide one in arriving at his conclusion for or against drainage.

When one opens a pus pocket in operating for acute appendicitis, and the immediate peritoneal field is soiled in sponging out the pus, he should not drain, provided the appendix can be removed and its base crushed and inverted. Here one would fear more the infection of the muscle planes, knowing that if the cause be removed the soiling of the peritoneal field will not give rise to trouble. In such a case a small rubber tissue drain should be inserted down to the peritoneum, but not through its line of suture.

Similarly in a case of acute appendicitis where there is much free cloudy exudate, but few adhesions, only moderate injection of the peritoneum, and that shading off as one proceeds from the site of the appendix, he should not drain; knowing that here, too, the peritoneum will take care of itself, even if the surrounding peritonitis takes several days to subside.

Where a dry exudate is met with in acute appendicitis, a drain could not help or relieve the condition, and should not be used.

In cases where the bowel and mesentery look gray-green as the result of swelling and the presence of the diphtheritic-like membrane, a drain should be placed down to the gut but not pressing on the area under suspicion. This drain should be removed at the end of 24 to 48 hours if the general and local symptoms have abated. By early removal of the drain one avoids the formation of a rigid tube of granulating tissue which would form a sinus of long duration. If perforation occurs, the discharges will find their way along the line of least resistance and reach the surface of the body.

In dealing with cases requiring division of the parietal peritoneum, exposing the retroperitoneal bed of some organ in the presence of infection, a different proposition confronts one. One is here dealing with cellular tissue, and not with the peritoneum, possessed of its wonderful powers of resistance and recuperation; such an area must, therefore, be drained.

In this discussion no account has been taken of the nature of the infecting agent, and properly so; one must be guided by the gross appearance of things, and not by the bacteriology; as this can seldom be known at the time of operation.

The general subject of peritonitis and its treatment is dealt with elsewhere in this work, and a further discussion of the subject of drainage in this connection would be superfluous.

The types and forms of drains will not be discussed, except to say a word of warning as to the use of rigid drains in the neighborhood of a diseased bowel and near large blood vessels. Such drains are apt to cause perforation of the bowel and necrosis in the walls of those vessels already damaged by the presence of infection in the wound.

Closure of the Wound.—The operation finished, a review of the field should be made. Any doubtful suture or ligature should now engage the operator's attention, for the success of the operation depends on the work done in the operating room, and not on what one might wish to have done after the patient has been returned to bed. The lymphatic area draining the region, in operations for malignant growths, should be carefully inspected that nothing be left which could with safety have been removed. All pads and instruments having been accounted for, the surgeon may proceed to close the wound.

The layer-by-layer closure is the best, suturing the peritoneum with a running catgut stitch that brings the serous surface of the peritoneum into broad, even apposition and soon shuts off the peritoneal cavity from the rest of the wound, preventing its contamination if any infection develops later in the muscle layers.

Aponeuroses are best sutured with chromic gut. They need not be overlapped, as even apposition gives as strong union and more likelihood of sound healing. Aponeuroses stripped of their blood supply have enough to contend with in resisting infection without being strangulated by too much suturing. Muscles, where cut across, should be carefully approximated by near and distant sutures, the first to obtain even union, the second to secure relaxation. Where separated or displaced, 1 or 2 interrupted catgut sutures will secure them in the position desired. The subcutaneous fascia, holding in its mesh the fat of the abdominal wall, should always be united by interrupted catgut sutures. This will obliterate all dead spaces and prevent subsequent widening of the skin incision. Silk is the best suture material for the skin, as it can be quickly introduced, has considerable holding power, and rarely gives rise to stitch abscess unless infected from beneath.

The subcuticular suture has many advocates, but if the scar be examined 6 months after the operation, the fine silk stitch will show as good results as the subcuticular one. The infection of the stitch hole from the skin has been greatly exaggerated. In this only has the subcuticular stitch any advantage over the silk suture.

Relaxing sutures of various materials are sometimes necessary, but if the abdominal wounds are closed in the manner above described, support other than that given by a well applied dressing will not be needed.

Hasty closure of the abdominal wound is seldom necessary or justifiable. The surgeon can begin the postoperative care of his patient on the table, as hurrying him from the operating room with an incomplete suture of his wound will not improve his chances of recovery.

Non-absorbable sutures are required in the closure of wounds of very old people; of those suffering from malignant diseases found to be inoperable; and those whose tissues have long been stained with bile pigment. Patients with inoperable conditions can thus the sooner be gotten out of bed, and those with chronic jaundice have the tendency of their wounds to open diminished. Silk or linen may be used for these buried sutures.

Where the abdominal wall fails to relax owing to distention, or where the anesthetic fails to give relaxation, as in paraplegic conditions, the through-and-through suture must be used. Silkworm-gut is the best material for this method of suturing. The objectionable features of this method lie in its not bringing the aponeurotic layers together, and its speed in cutting through tissues under tension, thus giving rise to infection along its tract to tissues already undergoing necrosis from pressure.

Clean, dry wounds need no drainage. Where one fears that the wound may have been contaminated from work within the abdomen, a folded rubber tissue drain should be placed in either end of the wound, and need not be removed, if no infection develops, until the silk sutures uniting the skin are cut on the seventh or eighth day.

The Dressing.—Dry, clean wounds require little dressing. Two or three layers of folded gauze, held in place by long encircling bands of zinc-oxid adhesive plaster that grip the skin at the margins of the narrow, folded gauze pad, so placed as to give support to the wound and relaxation to its edges, complete the essential dressing. Over this may be placed sufficient cotton to allow the binder to be fitted smoothly and snugly.

Drained wounds can be so arranged so as to allow the more bulky portion of the dressing to be changed from time to time. The judicious use of adhesive strapping will do away with tension sutures and aid much in the proper healing of the wound. A well strapped wound will allow freedom of movement during convalescence. All exercises that do not entail movement in the wound should be encouraged, as they aid materially in bringing about a speedy recovery.

POSTOPERATIVE TREATMENT

This should be as simple and as little meddlesome as possible.

Pain.—Pain from the operative procedure is rarely severe or long-continued. A single dose of morphin will tide the patient over the period of its continuance. After this, if the pain or discomfort continue, it is due to some other cause and must be treated by measures other than the administration of morphin.

Thirst.—This is bound to be present in operations of long duration. Administration of water in large amounts before operation, and tap-water by rectum after operation, will tend to diminish its intensity. Water by mouth should not be withheld if the vomiting produced by its administration is not continued. Ice and ice-cold water are of little value, either for thirst or nausea, and should not be given. The measures instituted for the relief of meteorism, to be detailed, also aid in diminishing the thirst.

Nausea and Vomiting.—If one will observe the nausea and vomiting seen in the alcoholic wards of any big metropolitan hospital, pause a moment to think of its cause, and then compare it with the nausea and vomiting seen after the administration of ether, he will be struck by the great similarity of the picture. In either case it is produced by an overwhelming dose of a drug. Its treatment is its prevention.

Any procedure that diminishes the amount of the anesthetic, whether it be the speed of the operator himself in shortening the time of the operation, the skill of the anesthetizer in giving the minimum quantity of ether, or the use of nitrous oxid or of nerve-blocking solutions, both lessening the amount of the anesthetic required, makes to this end. The shock of the operation, and the train of symptoms attendant on the inhibition of normal peristalsis arising from the handling of the intestines, from mild traumatic peritonitis, or from more or less severe septic peritonitis, are added to the effects of the ether.

The use of large drains, the ligation of omentum and operations upon the alimentary tract itself, all interfere with normal function by a reflex inhibition. Until the peritoneum has sealed the operative field, or until the septic or traumatic peritonitis has limited itself, this reflex inhibition of normal peristalsis will persist. During this time the patient can be relieved of some of the discomfort attendant on this condition by gastric lavage.

In acute gastric dilatations, reversed peristalsis, and the persistent vomiting of septic peritonitis lavage is the only measure that gives any appreciable relief. This relief is so great that the patients suffering from any of the abovementioned conditions, incredible as it sounds, welcome each washing for the freedom from conditions well nigh intolerable.

Meteorism.—Meteorism, which is a later accompaniment of arrest of peristalsis, may not be prominent if the patient has had his bowels thoroughly emptied by a large dose of castor oil before operation. The preventive measures that are useful in lessening the nausea and vomiting serve the same end in this condition. When meteorism is present, high colonic irrigations, large soapsuds enemata, and the use of the rectal tube will give the greatest relief.

It is well here to emphasize the importance of making a thorough physical examination of all patients who do not do well after an operation. Thus it will be easier to recognize acute gastric dilatation from meteorism, and the appropriate treatment can be instituted without loss of time. Repeated gastric lavage, change of position, turning the patient on his right side, or elevating to a sitting posture, will bring through many a case of acute gastric dilatation.

It is useless to try to cause a bowel movement by means of cathartic medication during this period of intestinal inhibition. It may do actual harm by causing activity in the small intestine when nature is trying to hold it still and thus limit the spread of some inflammatory condition. The relief from gas is all that is necessary during this time, and this is better accomplished by soapsuds enemata and the use of the rectal tube.

Mechanical Ileus.—Mechanical ileus, when the diagnosis can be made, calls for immediate reopening of the abdomen. The absence of the signs of peritonitis, the failure of gastric lavage and colonic irrigation to give relief, the asymmetry of the distention, and the lack of abdominal rigidity in the presence of active peristaltic movements are some of the signs that point to this condition. Often there will be some step in the operation (the placing of some drain, the too short loop used in bringing about an anastomosis, the leaving of raw surfaces unprotected by omentum) that will give the operator some clew to the causation of the condition.

Foreign Bodies.—Aseptic foreign bodies left in the abdomen, if they do not give rise to obstruction, develop the symptoms of their presence after 10 or 12 days. These are pain and tenderness, slight rigidity if near the parietal wall, slight rise of pulse and temperature, in fact, the evidence of a local protective peritonitis.

I recovered a small square of gauze that my assistant had cut from a pad and used to temporarily pack a sinus while scrubbing up the abdomen for a pelvic operation. It had been thrust well down the sinus, thinking that it would be recovered when the scar had been circumscribed and the sinus followed into the abdomen. It was not found in the sinus, having been thrust through into the free peritoneal cavity. Though vigorous search was made before proceeding with the operation, its position could not be discovered. The pelvic work, which consisted in the removal of a suppurating tube and ovary of gonorrheal origin, having been completed, my assistant, putting on clean gloves, asked leave to make a further search. This, too, proved fruitless, and the abdomen was closed with drainage, in the hope that the lost piece would somehow establish a communication with the drain in the wound. It did not, for the wound healed without suppuration and remained permanently closed.

Ten days later the patient complained of pain on the right side beneath the liver. This was accompanied by a rise in pulse and temperature (which had previously touched normal several days before) and distinct rigidity of the abdominal wall in the region of the liver.

Through a high intermuscular incision the abdomen was opened, and lying in front of the hepatic flexure of the colon, the lost piece was found surrounded by a protective peritonitis in the shape of an abscess walling in the gauze. The patient's recovery was uneventful.

In these days of improved technic there is little danger of such an accident happening with pads and their attached tapes, but sponges may easily become lost from a sponge-holder unlocking, and thus releasing the piece of gauze in its grip.

Diet after Operation.—The less one attempts to feed a patient after an operation the better. Water, for the first 24 hours, is all they desire and all they require. In short, uncomplicated cases patients often desire food on the second day, and there is no reason why it should not be given them. Patients who have had longer and more serious operations and suffer from the various disagreeable effects of the ether and the operation, require to have their regular diet restored more gradually. These can be given albumen water, combined with either orange or lemon juice, clear broths, clam juice, and the various "soft-solids" on the second day. As a rule, solid food is not desired until the patients have had their first complete evacuation of the bowels.

Rectal feeding will often be of use in helping out the very debilitated and those having had operations on the stomach. In stomach cases surgeons are giving water and albumen water by mouth as early as the second day, with as good results as obtained when feeding by mouth was delayed till the tenth day or later.

Excretion of Urine.—After operation the excretion of urine is always scanty, and catheterization for retention need not be done, unless on account of pain, inside of 18 hours. In this way much of the postoperative catheterization can be avoided. In cases where the peritoneum of the bladder is involved in a local peritonitis, retention is more pronounced and the catheter will have to be used earlier and more frequently.

Suppression or scanty excretion is best treated by high colonic irrigation given every 4 hours. This treatment must be persisted in until results are obtained or the patient dies.

Peritonitis.—Peritonitis developing after operation, or the further extension of one already existing at the time of operation, must be treated as idiopathic except where one is sure that it is due to some fault in technic, as the giving way of the line of suture or the secondary perforation of the bowel, as in typhoid ulceration. Here the abdomen must be opened as soon as possible and the fault remedied.

Bronchitis and Pneumonia.—Bronchitis and pneumonia must be treated as these conditions demand when not the result of operative procedure. Much can be done in the line of prevention, both by the operator and by the anesthetist; by the operator, in not undertaking an operation upon a patient suffering from some respiratory condition, unless driven by necessity; by the anesthetist, by care in the administration of the anesthetic, especially as regards the inhalation of secretions and vomitus.

Hemorrhage, following operation, as evidenced by restlessness, weak and ever-increasing pulse, pallor, and air-hunger, demands the opening of the abdomen at once, securing the bleeding point, and then infusion of salt solution, or, better still, transfusion, if a suitable donor is at hand.

Extreme restlessness alone indicates the beginning of a peritonitis or the onset of delirium tremens.

Pulmonary embolism and mesenteric thrombosis are happily among the rarer postoperative complications, and as their prevention and treatment are beyond our control, it is fortunate that it is so.

Acute mania is apt to be transitory, unless it is the exacerbation of an underlying condition not previously recognized.

Phlebitis.—The surgeon should be on the watch for this condition, as his failure to recognize it as the cause of an increase in pain, pulse, temperature, and restlessness may result in meddlesome exploration of the wound. It is usually left-sided, occurring in the saphenous or femoral veins.

Restlessness and sleeplessness are inevitable after most operations. The backache, pains in the legs, and the annoying gas-pains, which are accountable for most of the discomfort and sleeplessness following operations, can be relieved in part by change of position, by pillows placed under the knees and back, and by frequent massage with alcohol. Small doses of phenacetin will often quiet the restlessness better than morphin, which should be given only for severe pain.

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